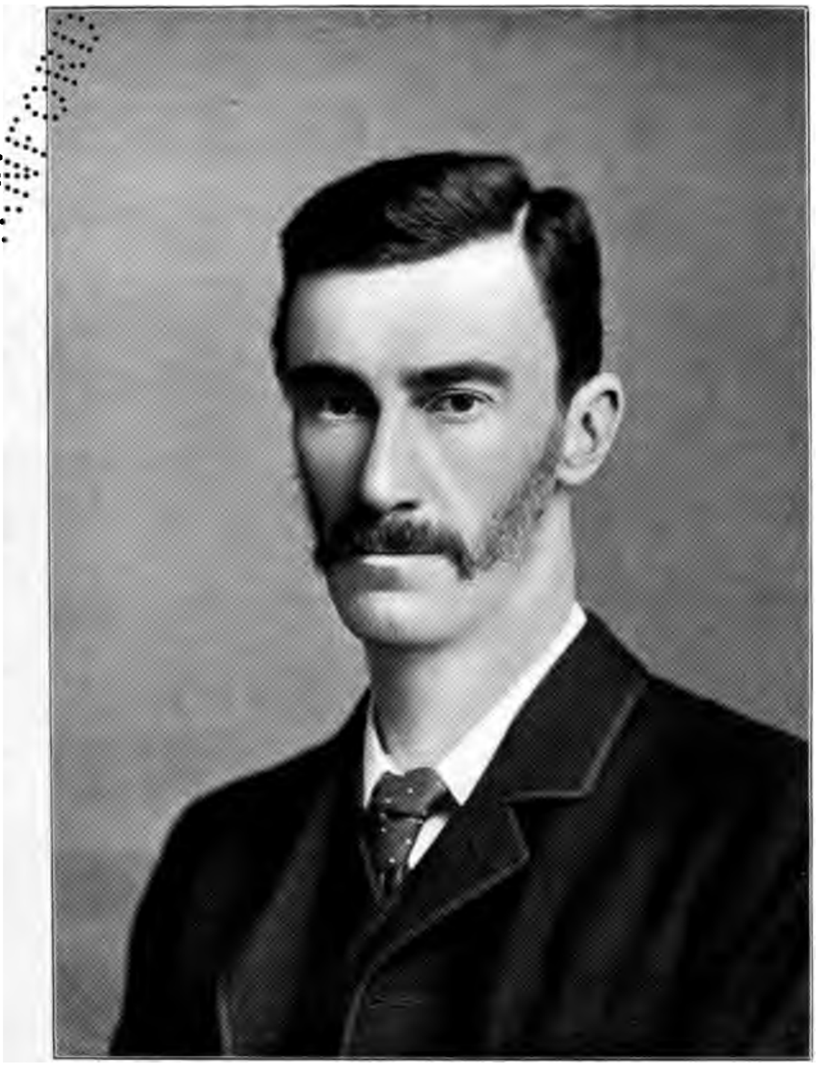

WILLIAM HENRY DINES, B.A.

(*President of the Royal Meteorological Society* 1901-1902.)

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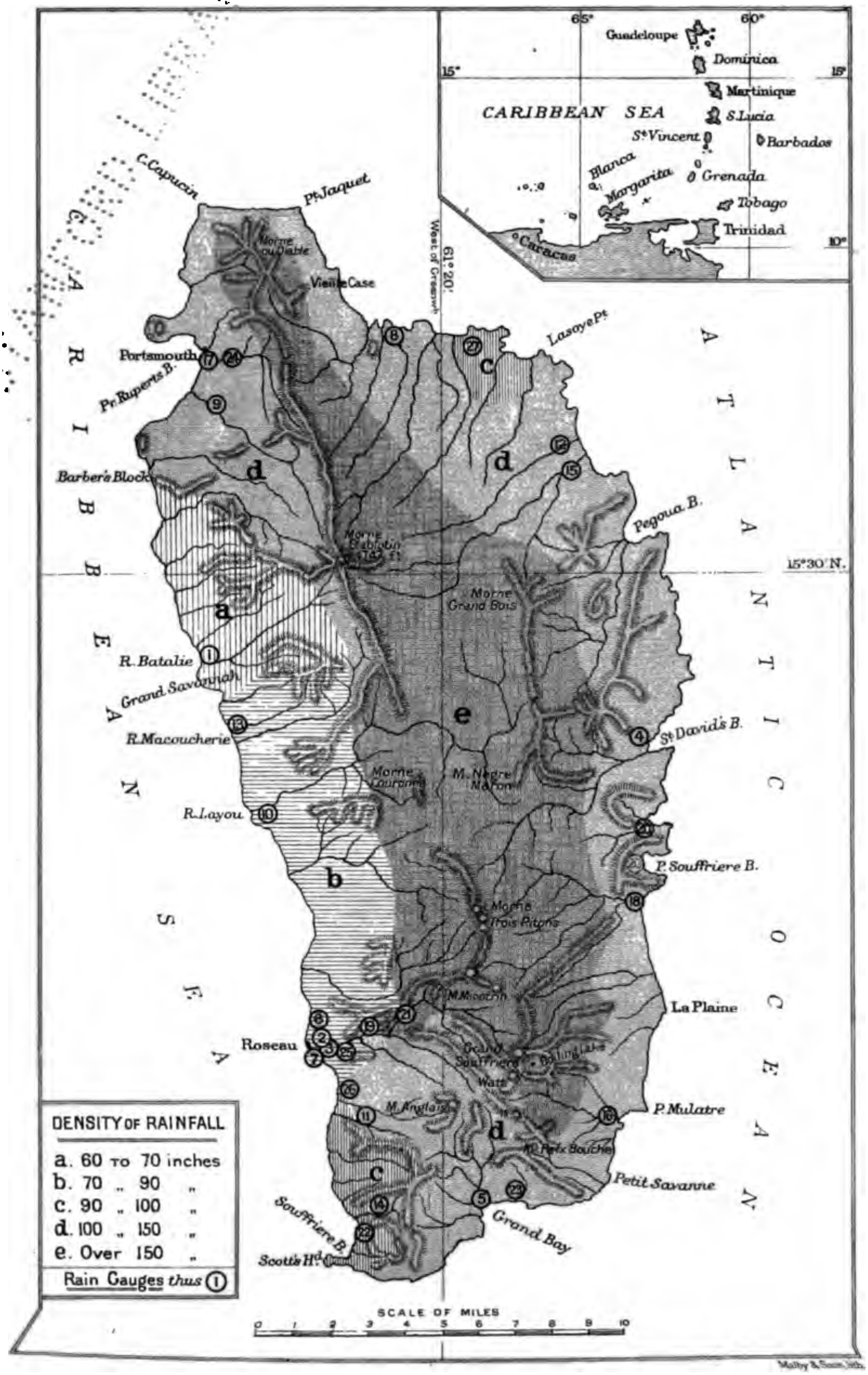

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By FRANCIS CAMPBELL BAYARD, LL.M., F.R.Met.Soc.

[Read November 19, 1902.]

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In the decade 1881-1890 there were 52 stations with continuous, or nearly continuous, records; and in the decade 1891-1900 there were 69 stations. Of this number the Fellows will be glad to know that there are 40 stations (see the particulars in Table I.) the records of which are continuous, or nearly so, for the whole 20 years under review, and of these 34 are in England, 2 in Wales, 3 in Ireland, and 1 in the Channel Islands. Unfortunately, however, the distribution of these stations is such (see Map) as to preclude the drawing of lines of equal value for the different elements with anything like scientific accuracy. Possibly the gaps in the distribution of the stations might have been filled by importing the records of stations published elsewhere; but whilst some of the records required are perfectly reliable, and cover the whole of the period, others are unfortunately not, so I have thought it advisable to confine this discussion solely to the stations shown in *The Meteorological Record*.

The records given in this paper have been obtained by simply adding together the means contained in the two previous papers, and then dividing by two in every case, with the single exception of the rainfall at Ilfracombe. In this case the rain-gauge was for the first 10 years kept 9 ft. above the ground, and for the second 10 years at 1 ft.; and in order to form a proper comparison the record of the first 10 years was reduced to 1 ft. by means of the table[1] given in my second paper, and then the

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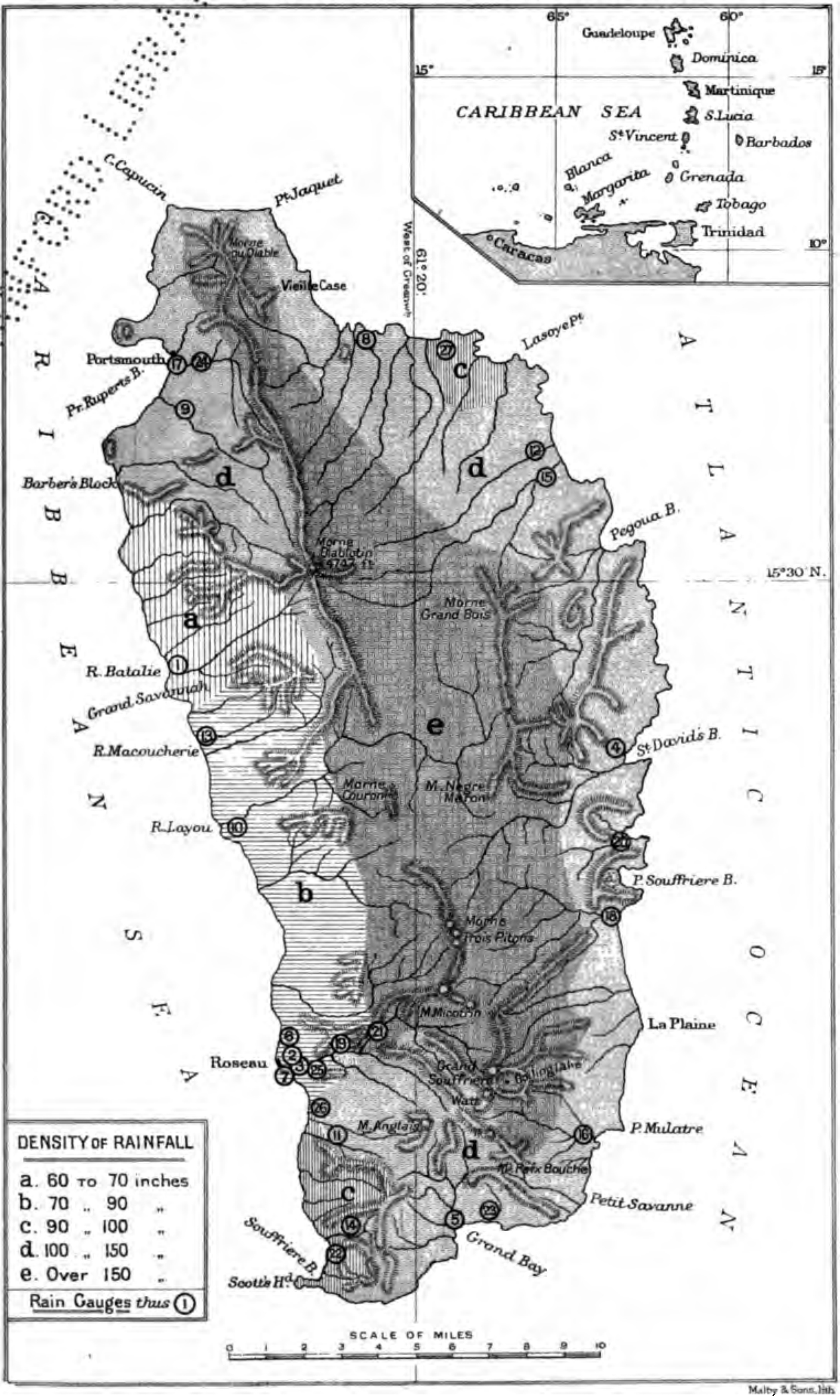

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[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxviii. p. 271.

record thus found was dealt with in conjunction with the second record, in accordance with the rule just given.

If we look at Table I. we shall at once be struck with the fact that some of the stations have been moved, and the heights above sea-level have been altered. How far this has affected the records of temperature and rainfall is uncertain; but having regard to the fact that the period

Map showing the Position of the Stations.

dealt with is 20 years, it is, I think, a fair presumption to make that any differences occasioned by such removal must necessarily be small.

Table X., giving the corrections for the reduction of the temperatures to sea-level for the different stations, has been constructed from the formula given by Dr. Buchan in Bartholomew's *New Physical Atlas* (vol. iii. *Meteorology*, p. 6), which is + 1°·0 for every 270 feet in height above sea-level; and it has been presumed that this correction is applicable to the 9 a.m., the minimum, and the maximum temperatures, as well as to the mean temperatures. Wherever the station during the period under review has been altered, a mean height has been taken for the purpose of

TABLE I.—STATIONS AND AUTHORITIES.

STATION.	COUNTY.	Height above Sea-level.	AUTHORITY.
ENGLAND, N.E.		Ft.	
Scarborough	Yorkshire	130	F. Shaw. A. Rowntree.
		160	W. Robinson; H. G. Monk, M.D.; H. Littlejohn, F.R.C.S.; E. W. Ellerbeck, F.R.A.S.
		219	E. W. Ellerbeck, F.R.A.S.
		62	W. W. Larkin.
ENGLAND, E.			
Hillington	Norfolk	89	Rev. H. E. B. Ffolkes, M.A., F.R.Met.Soc.
Lowestoft	Suffolk	84	S. H. Miller, F.R.Met.Soc. J. E. O'Connor, M.B., F.R.Met.Soc.
MIDLAND CO.			
Wakefield	Yorkshire	96	H. Clarke, L.R.C.P., F.R.Met.Soc. A. Clyde.
Hodsock	Notts	56	H. Mellish, J.P., F.R.Met.Soc.
Buxton	Derby	987	E. J. Sykes, M.B.; W. H. Beck; F. H. Bowden; F. E. Gunter, M.B.; E. A. Dent, M.B.; H. Harrison; H. L. Apthorp; W. Pilkington.
Belper	Derby	344	J. Hunter, F.R.Met.Soc.
Cheadle	Stafford	646	J. C. Philips, J.P.
Churchstoke	Montgomery	538	P. Wright, F.R.Met.Soc.
Burghill	Hereford	275	T. A. Chapman, M.D. C. S. Morrison, M.B.
Ross	Hereford	213	H. Southall, J.P., F.R.Met.Soc.
Cheltenham	Gloucester	184	R. Tyrer, B.A., F.R.Met.Soc.
Aspley Guise	Bedford	410	E. E. Dymond, J.P., F.R.Met.Soc.
ENGLAND, S.			
Regent's Park	London	125	W. Sowerby, F.R.Met.Soc. J. B. Sowerby.
Norwood	Surrey	184 220	W. Marriott, F.R.Met.Soc.
Beddington	Surrey	102 120	S. Rostron, J.P., F.R.Met.Soc.
Marlborough	Wilts	471	Rev. T. A. Preston, M.A., F.R.Met.Soc.
		424	C. E. B. Hewitt, B.A.; J. A. Ensor; J. Frith; W. Clement Jones, D.Sc.; R. S. Cole; Science Master.
Harestock	Hants	300	Lt.-Col. H. S. Knight, F.R.Met.Soc.
Swarraton	Hants	310	Rev. W. L. W. Eyre, M.A., F.R.Met.Soc.
Margate	Kent	83	J. Stokes, J.P., F.R.Met.Soc.
Brighton	Sussex	31	A. Newsholme, M.D., F.R.Met.Soc.
Worthing	Sussex	21	W. J. Harris, F.R.C.S., F.R.Met.Soc.
		33	W. J. Harris, F.R.C.S., F.R.Met.Soc. G. B. Collet, L.R.C.P., F.R.Met.Soc.
		38	C. Kelly, M.D., F.R.Met.Soc.
Portsmouth	Hants	20	R. E. Power, L.R.C.P.
		18	B. H. Mumby, M.D., F.R.Met.Soc. A. M. Fraser, M.D.

TABLE I.—STATIONS AND AUTHORITIES—*continued.*

STATION.	COUNTY.	Height above Sea-level.	AUTHORITY.
		Ft.	
Ventnor . . .	Isle of Wight .	80	J. Codling; H. Sagar; H. Cleeland; W. R. Watkins; C. Lewis, M.B.; Miss M. Gibson.
Weymouth . .	Dorset . .	79	T. B. Groves, F.C.S., F.R.Met.Soc. J. R. Eyles, F.R.Met.Soc. I. J. Brown, F.R.Met.Soc.
ENGLAND, N.W.			
Scaleby . . .	Cumberland .	111	R. A. Allison, J.P., F.R.Met.Soc.
Seathwaite . .	Cumberland .	422	W. Dixon. Mrs. Hughes.
Macclesfield . .	Cheshire . .	501	J. Dale. C. Roscoe.
Blackpool . . .	Lancashire .	31 62	Rev. C. T. Ward, B.A. J. Wolstenholme, Assoc.M.Inst.C.E. A. J. Anderson, M.B.
Llandudno . .	Carnarvon .	79 88 72	J. Nicol, M.D., J.P., F.R.Met.Soc. W. Little.
ENGLAND, S.W.			
Weston-super-Mare .	Somerset . .	22	W. E. Perrett.
Ilfracombe . .	Devon . .	20	W. M. Tattam.
Cullompton . .	Devon . .	202	T. Turner, J.P., F.R.Met.Soc.
Ashburton . .	Devon . .	584	F. Amery, J.P.
Sidmouth . . .	Devon .	186 148	W. T. Radford, M.D., F.R.Met.Soc. W. T. Radford, M.D., F.R.Met.Soc. Miss Radford.
Falmouth . . .	Cornwall .	210 175 167	W. L. Fox, F.R.Met.Soc. E. Kitto, F.R.Met.Soc.
IRELAND.			
Londonderry . .	Londonderry .	67	J. Conroy, F.R.Met.Soc.
Dublin . . .	Dublin . .	47	Sir J. W. Moore, M.D., F.R.Met.Soc.
Killarney . . .	Kerry . .	86	Ven. Archdeacon Wynne, D.D.
CHANNEL ISLANDS.			
Guernsey . . .	Channel Islands	180	F. E. Carey, M.D., F.R.Met.Soc.

The names of the Second Order Stations are printed in italics.

the correction to sea-level. With reference to the relative humidity table no correction can be given for reduction to sea-level, nor for the rainfall table; and as far as I am aware, no experiments have ever been undertaken with the view of constructing the necessary formula for these corrections.

Having regard to the above remarks, it has seemed desirable to give the actual figures without any correction in the tables, and to show up the salient features in them by printing the highest and lowest values in thick and italic type.

Temperature.

In dealing with this element of climate, the first point to be noticed in Tables II. and V. is that the mean yearly temperature is lower than the mean yearly temperature at 9 a.m. at every station except 7, and these stations are Belper, Cheadle, Regent's Park, Macclesfield, Weston-super-Mare, Dublin, and Guernsey. On comparing the January figures in these tables we find that the mean temperature is higher than that at 9 a.m. in every case except 6, in 5 of which, viz. Buxton, Blackpool, Llandudno, Ilfracombe, and Killarney, it is equal; and in only 1, viz. Weymouth, is it less, and then only by 0°·1. In April we have the 9 a.m. temperature higher than the mean temperature in all except 8 stations, in 1 of which, viz. Regent's Park, it is equal; and in the 7 others, viz. Belper, Cheadle, Seathwaite, Macclesfield, Weston-super-Mare, Dublin, and Guernsey, it is less; and it is worthy of note that these 8 cases include every one of the 7 stations in the annual columns. In July we have the 9 a.m. temperature higher than the mean temperature in all cases except 4, in 1 of which, Dublin, it is equal; and in the other 3, viz. Belper, Cheadle, and Macclesfield, it is less; and these 4 stations are amongst the 7 in the annual columns. Whilst in October we have a somewhat different state of things, for we have the 9 a.m. temperature higher than the mean temperature in only 22 cases out of 40, and of the remaining 18 stations, 4, namely, Hillington, Ross, Swarraton, and Portsmouth, are equal, and in the other 14, viz. Wakefield, Hodsock, Belper, Cheadle, Regent's Park, Norwood, Boddington, Scaleby, Seathwaite, Macclesfield, Weston-super-Mare, Londonderry, Dublin, and Guernsey, it is less; and it is noticeable that, like April, these excepted stations include the 7 stations in the annual columns. Is it possible that the observations at these 7 stations are taken too early? This may be the reason why we do not find them; and it is noticeable that of these 7 exceptions 4 are in the 3 months of April, July, and October, and the remaining 3, Regent's Park, Weston-super-Mare, and Guernsey with Seathwaite, are only in April and October.

If we now turn to Table III. we note that the minimum occurs in January in all cases except 5, 3 of which, viz. Wakefield, Seathwaite, and Ilfracombe, have their minimum in February; whilst in the other 2 cases, viz. Llandudno and Falmouth, there is besides January a second month with the same minimum temperature as the January minimum, viz. February at Llandudno, and March at Falmouth, and it is noticeable that these 2 stations are maritime stations somewhat peculiarly situated. The maximum occurs at all inland stations in July, with the single exception of Killarney. With respect to the maritime stations the maximum occurs in August, with 6 exceptions, viz.—as to Lowestoft and Brighton the maximum occurs both in July and August, the two months being of equal value; and as to the remaining 4 stations, viz. Scarborough, Blackpool, Weston-super-Mare, and Dublin, in July. It will be noticed that 2 of these stations, viz. Blackpool and Weston-super-Mare, are on the west coast, and of the other 2, Scarborough is on the east coast of England, and Dublin on the east coast of Ireland. Unless one knows something more about the actual situation of these stations, it seems difficult to imagine any reason for these discrepancies, except perhaps in the case

TABLE II.—MEAN TEMPERATURE AT 9 A.M., 1881-1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.													
Scarborough .	*38·0*	38·4	40·7	45·5	50·7	56·7	**60·3**	59·6	55·9	48·5	44·0	39·0	48·1
ENGLAND, E.													
Hillington . .	*35·6*	37·2	40·5	47·2	53·6	59·9	**62·6**	61·6	57·1	48·3	42·6	37·0	48·6
Lowestoft . .	*37·3*	38·4	41·0	46·3	52·2	58·5	**62·3**	62·0	58·5	50·5	44·7	39·0	49·2
MIDLAND CO.													
Wakefield . .	*37·4*	37·8	39·8	45·4	52·1	58·3	**60·9**	59·7	55·5	47·1	43·2	38·4	48·0
Hodsock . .	*36·0*	37·2	40·6	46·5	53·1	59·1	**62·0**	60·7	56·3	47·5	42·4	37·2	48·2
Buxton . .	*34·9*	35·5	38·3	43·8	50·4	56·8	**58·6**	57·7	54·1	45·8	41·0	35·8	46·1
Belper . . .	*36·1*	36·8	39·2	44·7	50·9	57·2	**59·6**	58·1	53·7	45·9	42·0	37·4	46·8
Cheadle . .	*35·0*	35·7	38·3	43·9	49·9	55·9	**58·0**	57·0	53·7	45·5	41·2	36·4	45·9
Churchstoke . .	*36·7*	37·5	40·1	45·5	52·0	58·4	**60·4**	59·4	55·3	47·3	43·0	38·0	47·8
Burghill . .	*36·8*	37·9	41·4	47·1	54·0	60·5	**62·8**	61·6	56·6	47·6	43·1	38·1	49·0
Ross . . .	*37·4*	38·4	41·8	47·6	54·4	60·8	**63·3**	62·1	57·1	48·3	43·9	38·8	49·5
Cheltenham . .	*37·5*	38·3	40·9	47·0	53·2	59·5	**62·0**	61·2	56·3	47·7	43·6	38·9	48·8
Aspley Guise .	*36·2*	37·2	40·8	46·8	53·4	59·6	**63·0**	61·8	57·0	48·5	42·9	37·6	48·7
ENGLAND, S.													
Regent's Park .	*37·9*	38·5	41·0	47·4	54·3	60·6	**63·6**	62·1	57·6	48·6	44·4	39·4	49·6
Norwood . .	*37·3*	38·3	41·3	47·8	54·6	60·9	**64·0**	62·7	58·1	49·0	44·0	38·6	49·7
Beddington . .	*36·7*	37·7	40·7	47·5	54·5	60·7	**63·9**	62·6	57·5	48·1	43·2	37·9	49·3
Marlborough .	*36·3*	37·2	40·1	46·5	53·0	59·0	**62·1**	61·2	56·4	47·4	42·4	37·6	48·3
Harestock . .	*37·0*	37·9	41·0	47·4	53·8	59·8	**62·7**	61·9	57·5	48·7	43·6	38·4	49·1
Swarraton . .	*36·6*	37·3	40·1	46·3	53·0	58·9	**61·5**	60·9	56·5	47·8	42·8	38·0	48·3
Margate . .	*38·3*	39·1	41·8	47·3	53·2	59·0	**62·8**	62·7	59·1	51·0	45·7	40·4	50·0
Brighton . .	*39·5*	40·2	42·5	48·4	55·4	60·7	63·8	**64·0**	60·4	52·4	46·9	41·5	51·3
Worthing . .	*38·7*	39·6	42·0	48·2	54·3	60·0	**62·9**	**62·9**	59·6	51·2	46·0	40·7	50·5
Portsmouth . .	*39·1*	39·8	42·2	48·2	54·7	60·6	**63·6**	63·2	59·2	51·0	45·9	41·0	50·7
Ventnor . .	*40·8*	41·4	43·6	48·7	54·5	59·8	62·8	**63·2**	60·2	53·0	48·0	43·2	51·6
Weymouth . .	*41·2*	*41·2*	42·9	47·7	53·4	59·2	**62·3**	**62·3**	59·0	52·1	47·7	43·4	51·0
ENGLAND, N.W.													
Scaleby . .	*36·5*	36·9	39·4	45·7	51·9	58·0	**59·5**	58·8	54·7	46·3	41·9	37·5	47·3
Seathwaite . .	37·7	*37·2*	38·5	44·9	51·3	58·1	**58·7**	57·6	53·7	46·0	42·4	39·0	47·1
Macclesfield .	*35·9*	36·3	38·1	44·1	50·4	56·5	**58·4**	57·3	53·4	45·3	41·6	37·2	46·2
Blackpool . .	*38·2*	38·6	41·0	46·6	52·5	58·6	**60·5**	60·0	56·7	49·0	44·5	39·5	48·8
Llandudno . .	*41·1*	41·3	42·7	47·3	52·7	58·6	**60·7**	60·4	57·8	50·8	46·7	42·5	50·2
ENGLAND, S.W.													
Weston-super-Mare	*39·7*	39·9	42·1	47·6	53·5	59·6	**62·5**	62·0	58·2	50·4	46·0	41·4	50·2
Ilfracombe . .	*43·1*	*43·1*	44·4	48·3	52·7	58·6	61·4	**61·7**	59·4	53·2	48·9	44·8	51·6
Cullompton . .	*38·8*	39·6	42·6	48·3	54·7	60·7	**63·1**	62·3	58·0	49·6	44·7	40·1	50·2
Ashburton . .	*40·1*	40·7	43·2	48·5	53·9	59·9	**62·1**	61·6	58·3	51·1	46·3	41·9	50·6
Sidmouth . .	*40·3*	40·8	42·8	47·6	53·5	59·0	**61·8**	61·7	58·2	50·8	46·5	42·3	50·4
Falmouth . .	*42·9*	43·3	44·7	49·1	53·9	59·6	**62·1**	61·9	59·1	52·7	48·6	44·9	51·9
IRELAND.													
Londonderry .	*39·3*	40·1	41·8	47·3	53·7	59·0	**60·0**	59·0	54·9	47·6	43·8	40·4	48·9
Dublin . .	*40·5*	41·1	42·3	47·3	53·2	58·8	**60·3**	59·4	55·6	48·4	45·3	41·4	49·5
Killarney . .	*41·9*	42·8	44·3	48·8	53·6	59·0	**60·3**	59·8	56·9	50·2	46·5	43·1	50·6
CHANNEL ISLANDS.													
Guernsey . .	*42·7*	42·8	44·4	48·5	53·3	58·3	61·6	**62·0**	59·7	53·4	49·0	44·7	51·7

of Scarborough, which might be caused by the removals of the station to new positions.

In Table IV. we find that the lowest mean maximum temperature occurs at every station in January—a somewhat remarkable fact, as we might have expected that the temperature of the sea would have had more influence on the maritime stations. If we now turn to the highest mean maximum we shall find that this occurs in July, except in 5 cases which will be considered later on, and in 4 other cases, viz. Weymouth, Weston-super-Mare, and Sidmouth, where it occurs both in July and August, and Londonderry, where it takes place in June and July. It is somewhat difficult to account for this double maximum, but I cannot help thinking that the fact that they are all maritime stations has something to do with it. As to the remaining 5 cases, 1, viz. Seathwaite, where the highest maximum occurs in June, is probably caused by the comparatively small rainfall in that and the two preceding months and the increasing power of the sun, which in July and August is neutralised by the larger rainfall; and as to the other 4 cases, viz. Worthing, Ventnor, Ilfracombe, and Guernsey, which are all maritime places and have their highest maximum in August, this may possibly be due to the warmth of the sea, and this conjecture is in a way borne out by the respective neighbouring stations of Weymouth and Weston-super-Mare. It is, however, very difficult to conjecture why Brighton and Portsmouth should have their highest maximum in July, though perhaps in the case of Portsmouth this may possibly be due to some cool current, if there is one, running between it and the Isle of Wight. It is, however, somewhat difficult to understand also why Falmouth should have its highest maximum in July and not in August, when Sidmouth has it in both months, but possibly the headland in the case of Falmouth would make the difference of 0°·1 between July and August.

Relative Humidity.

This element is somewhat difficult to discuss, for there does not appear to be much known about atmospheric vapour beyond the fact that it exercises a most important function in determining climate. This will appear evident when we carefully consider Table VI. If we look at the annual column we shall find Cheadle, an inland station, and Guernsey, a maritime station, with the highest percentage, and Scaleby and Macclesfield, inland stations, and Ilfracombe, a maritime station, the next highest with a percentage of 85. Whilst with respect to the lowest values we have Llandudno, a maritime station, with 78, and Norwood, an inland station, with 79, and Regent's Park and Cullompton, inland stations, and Brighton, a maritime station, with 80. If we now turn to the maxima, we shall find that all the stations, except 6, which will be considered later, have the maximum in January, and that 9 of these, viz. Hillington, Hodsock, Churchstoke, Aspley Guise, Regent's Park, Marlborough, Harestock, Blackpool, and Dublin, have another maximum of the same value in either November or December, or both of these latter months, and it is remarkable that of these 9 stations only 1 is a maritime station, viz. Blackpool. With reference to the 6 stations, viz. Belper, Cheadle, Scaleby, Seathwaite, Cullompton, and Londonderry, whose maxima are

TABLE III.—Mean Minimum Temperature, 1881-1900.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Scarborough . .	*34°·0*	34°·5	35°·2	38°·8	43°·0	49°·4	**52°·4**	52°·3	49°·4	43°·1	39°·7	35°·0	42°·2
England, E.													
Hillington . .	*31·3*	32·2	33·0	37·1	42·1	48·2	**51·3**	50·8	47·3	41·2	37·5	32·7	40·4
Lowestoft . .	*33·4*	33·9	34·2	39·0	43·8	49·6	**53·1**	**53·1**	50·5	43·9	39·9	34·8	42·4
Midland Co.													
Wakefield . .	34·1	*33·4*	34·0	37·2	42·3	48·4	**51·5**	50·9	47·3	41·0	38·1	33·9	41·0
Hodsock . .	*31·5*	32·1	33·2	36·4	41·1	47·6	**51·0**	50·1	46·7	40·3	37·2	32·6	40·0
Buxton . .	*29·9*	30·0	30·5	34·5	39·2	45·5	**48·9**	48·3	44·4	38·5	35·4	30·8	38·0
Belper . . .	*31·9*	32·6	33·4	37·5	42·6	48·8	**51·8**	51·1	47·4	40·7	37·6	32·9	40·7
Cheadle . .	*31·8*	32·3	33·2	37·1	41·9	48·1	**50·9**	50·4	47·3	40·7	37·4	32·7	40·3
Churchstoke . .	*31·8*	32·2	32·5	36·1	40·6	46·8	**49·7**	49·2	45·9	39·8	37·2	33·0	39·6
Burghill . .	*32·5*	33·0	34·1	38·1	43·1	48·7	**51·6**	50·8	47·2	40·7	38·1	33·5	41·0
Ross . . .	*33·0*	33·4	34·3	38·5	43·3	49·3	**52·4**	51·6	47·8	41·2	38·8	34·2	41·5
Cheltenham . .	*32·4*	32·9	33·3	37·4	42·3	48·6	**51·3**	50·7	46·8	40·4	37·9	33·8	40·7
Aspley Guise .	*31·7*	32·2	33·2	36·9	41·9	48·3	**51·5**	51·2	47·7	41·1	37·4	32·7	40·5
England, S.													
Regent's Park .	*33·8*	34·4	35·4	39·7	45·0	51·1	**54·4**	53·8	50·0	43·1	39·8	34·9	43·0
Norwood . .	*33·5*	34·1	34·7	38·7	43·8	50·1	**53·3**	52·6	49·3	42·3	39·1	34·5	42·2
Beddington . .	*32·0*	32·9	33·7	37·5	42·7	48·9	**52·3**	51·5	47·8	41·1	37·6	32·9	40·9
Marlborough .	*31·6*	32·4	32·5	36·6	41·1	47·0	**50·0**	49·3	45·4	39·4	36·8	32·4	39·5
Harestock . .	*32·5*	33·0	33·4	37·4	42·4	48·5	**51·8**	51·3	47·9	41·2	38·0	33·8	40·9
Swarraton . .	*32·0*	32·7	33·1	37·0	41·8	47·8	**51·3**	50·7	47·2	40·5	37·6	33·1	40·4
Margate . .	*34·4*	35·1	36·3	40·4	45·4	51·4	54·7	**55·2**	52·4	45·5	41·0	35·8	44·0
Brighton . .	*35·3*	36·1	36·5	41·2	46·4	52·1	**55·6**	**55·6**	52·6	45·7	42·5	37·2	44·7
Worthing . .	*34·4*	35·3	35·7	40·4	45·4	51·1	54·5	**54·6**	51·5	44·7	41·1	36·1	43·7
Portsmouth . .	*34·4*	35·3	35·9	40·0	45·5	51·4	54·6	**54·9**	51·3	44·7	41·1	36·6	43·8
Ventnor . .	*37·2*	37·7	38·1	42·0	46·8	52·4	55·8	**56·5**	54·0	47·7	44·1	39·4	46·0
Weymouth . .	*36·9*	37·1	37·6	41·6	46·3	52·1	55·1	**55·6**	53·1	46·7	43·3	38·9	45·4
England, N.W.													
Scaleby . .	*32·1*	32·3	33·2	36·8	41·3	47·3	**50·3**	49·9	46·5	40·0	37·0	32·7	40·0
Seathwaite . .	33·5	*33·2*	33·9	38·2	42·8	48·9	**51·6**	51·1	47·6	41·1	38·3	34·4	41·2
Macclesfield .	*32·0*	32·8	33·4	37·6	42·2	48·5	**51·4**	51·1	47·5	40·7	37·7	33·1	40·7
Blackpool . .	*33·6*	34·1	34·9	38·6	43·3	49·7	**53·2**	52·9	49·6	42·9	39·4	34·9	42·3
Llandudno . .	*36·9*	*36·9*	37·4	40·9	45·3	51·3	54·1	**54·3**	51·5	45·5	42·1	38·2	44·5
England, S.W.													
Weston-super-Mare	*35·9*	36·1	37·0	41·4	46·3	52·4	**55·8**	55·3	51·9	45·5	41·8	37·3	44·7
Ilfracombe . .	39·5	*39·4*	40·0	43·5	47·9	53·6	56·4	**57·1**	54·4	48·9	45·3	41·3	47·3
Cullompton . .	*33·7*	34·3	34·6	38·6	43·2	48·8	**51·7**	50·9	47·5	41·4	38·9	34·7	41·5
Ashburton . .	*36·1*	36·4	36·9	40·8	45·3	51·0	**53·8**	53·7	50·9	45·0	41·8	37·7	44·1
Sidmouth . .	*35·9*	36·4	36·7	40·4	44·9	50·6	53·4	**53·5**	50·7	44·8	41·7	37·6	43·9
Falmouth . .	*39·2*	39·3	*39·2*	42·8	46·7	52·2	54·9	**55·1**	52·7	47·3	44·4	40·9	46·2
Ireland.													
Londonderry .	*35·0*	35·5	36·0	39·1	43·5	49·0	**51·2**	51·1	47·8	41·9	39·0	35·6	42·0
Dublin . .	*37·0*	37·5	37·4	41·4	45·6	51·6	**54·0**	53·5	50·1	43·8	41·3	37·6	44·2
Killarney . .	*36·1*	36·7	36·7	39·6	43·4	49·1	51·8	**52·0**	48·4	42·2	39·8	37·2	42·7
Channel Islands.													
Guernsey . .	*39·8*	40·0	40·5	43·9	47·8	52·6	55·9	**56·7**	55·1	49·5	46·0	41·7	47·5

TABLE IV.—MEAN MAXIMUM TEMPERATURE, 1881-1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.													
Scarborough .	*42°·1*	43°·4	46°·4	50°·2	55°·4	61°·9	**65°·8**	65°·0	61°·4	53°·3	48°·2	43°·4	53°·0
ENGLAND, E.													
Hillington . .	*41·5*	44·1	48·4	54·4	60·5	67·5	**70·6**	69·5	64·8	55·4	48·5	42·8	55·7
Lowestoft . .	*42·3*	43·6	46·5	50·7	56·4	62·9	**67·3**	67·1	63·8	55·7	49·8	44·0	54·2
MIDLAND CO.													
Wakefield . .	*42·9*	44·2	47·3	53·1	59·5	66·4	**68·1**	67·1	62·6	53·0	49·0	43·8	54·8
Hodsock . .	*42·6*	44·9	48·8	54·5	60·7	66·9	**69·6**	68·5	64·4	55·0	49·1	43·5	55·7
Buxton . .	*39·9*	41·8	44·8	51·0	57·3	64·0	**65·7**	64·8	60·6	51·6	46·1	41·3	52·4
Belper . .	*41·2*	43·1	47·0	52·9	58·9	65·4	**67·6**	66·2	61·9	52·9	47·5	42·4	53·9
Cheadle . .	*40·6*	42·6	46·1	52·2	57·9	64·1	**66·0**	65·1	61·1	52·3	47·0	41·8	53·1
Churchstoke . .	*42·3*	44·2	47·4	53·5	59·3	65·8	**67·6**	66·9	62·7	53·6	48·5	43·7	54·6
Burghill . .	*43·2*	45·5	49·5	55·7	62·2	68·7	**70·8**	69·8	64·9	55·3	49·4	44·3	56·6
Ross . . .	*43·3*	45·8	49·8	56·4	62·9	69·5	**71·5**	70·3	65·4	55·4	49·7	44·5	57·0
Cheltenham . .	*42·7*	45·0	48·5	55·0	61·5	68·1	**70·2**	69·2	64·6	54·9	49·5	44·3	56·1
Aspley Guise .	*41·2*	43·6	48·0	54·6	60·7	67·4	**70·5**	69·2	64·5	54·4	48·0	42·6	55·4
ENGLAND, S.													
Regent's Park .	*42·5*	44·3	48·5	55·2	62·0	68·9	**71·7**	70·4	65·5	55·5	49·4	44·1	56·5
Norwood . .	*42·7*	44·8	49·1	55·6	62·5	68·9	**71·9**	70·8	66·0	56·0	49·7	44·2	56·9
Beddington . .	*42·6*	44·7	48·9	55·7	62·3	68·9	**71·9**	70·7	65·8	55·8	49·6	43·7	56·7
Marlborough .	*42·3*	44·3	48·0	54·4	60·7	67·0	**69·5**	68·6	64·1	54·8	48·7	43·6	55·5
Harestock . .	*42·5*	44·9	48·9	55·2	61·0	67·5	**69·9**	69·2	65·0	55·7	49·6	44·2	56·1
Swarraton . .	*42·3*	44·4	48·1	54·7	60·8	66·7	**69·2**	68·5	64·2	55·1	49·2	43·8	55·6
Margate . .	*42·9*	44·1	47·4	52·3	58·5	64·8	**69·1**	68·5	64·6	56·0	50·3	44·8	55·3
Brighton . .	*44·3*	45·3	48·2	53·7	60·6	66·1	**68·6**	68·3	65·4	57·4	51·8	46·6	56·4
Worthing . .	*43·4*	44·8	47·8	53·3	59·9	65·4	67·7	**68·0**	65·1	56·9	50·8	45·4	55·7
Portsmouth . .	*44·1*	45·8	49·1	55·2	61·6	67·8	**70·4**	69·9	66·2	57·6	51·2	46·0	57·1
Ventnor . .	*45·2*	46·3	49·0	54·2	59·8	65·2	67·8	**68·2**	65·2	57·4	52·2	47·3	56·5
Weymouth . .	*45·2*	45·6	47·9	53·1	59·0	64·7	**67·5**	**67·5**	64·1	56·8	51·5	47·2	55·8
ENGLAND, N.W.													
Scaleby . .	*42·3*	44·1	47·1	53·0	59·4	65·7	**66·8**	65·8	62·2	53·7	48·0	43·1	54·3
Seathwaite . .	*41·9*	43·0	45·4	51·8	58·3	**64·8**	64·7	63·8	60·3	52·4	47·2	43·0	53·1
Macclesfield .	*41·3*	43·1	46·0	52·4	58·6	65·1	**66·5**	65·6	61·7	52·7	47·5	42·4	53·6
Blackpool . .	*42·7*	43·8	46·2	52·2	58·2	64·0	**65·5**	65·0	61·9	54·3	49·0	44·2	53·9
Llandudno . .	*45·2*	45·9	47·5	52·3	57·6	63·6	**65·5**	65·2	62·2	54·9	50·8	46·6	54·8
ENGLAND, S.W.													
Weston-super-Mare	*44·7*	46·1	48·7	54·3	59·9	65·9	**67·8**	**67·8**	64·5	56·5	51·0	46·3	56·1
Ilfracombe . .	*46·7*	46·9	48·3	52·8	57·8	63·3	65·4	**65·6**	63·1	56·6	52·5	48·5	55·6
Cullompton . .	*44·8*	46·4	49·7	55·8	61·7	67·9	**69·7**	69·0	65·4	56·6	50·8	46·3	57·0
Ashburton . .	*45·5*	46·7	49·7	54·8	60·3	66·3	**68·6**	67·9	64·6	57·0	51·7	47·2	56·7
Sidmouth . .	*45·3*	46·1	48·4	53·4	58·7	64·4	**66·9**	**66·9**	63·6	56·3	51·6	47·2	55·7
Falmouth . .	*47·0*	47·4	49·1	53·1	58·1	64·1	**66·3**	66·2	63·0	56·7	52·4	48·9	56·0
IRELAND.													
Londonderry .	*44·7*	46·5	48·9	54·8	60·3	**66·2**	**66·2**	65·5	62·3	54·2	49·3	45·5	55·4
Dublin . .	*45·8*	46·9	48·9	53·5	59·1	65·0	**66·5**	65·6	61·9	54·4	50·6	46·7	55·4
Killarney . .	*47·5*	47·9	50·1	54·6	59·3	64·8	**65·5**	65·3	62·5	55·8	51·8	48·7	56·2
CHANNEL ISLANDS.													
Guernsey . .	*46·5*	46·8	49·2	53·7	59·0	64·0	67·1	**67·5**	65·1	57·5	52·7	48·3	56·5

not in January, it will be noticed that only one, viz. Londonderry, is a maritime station. The maxima at these stations occur either in the months of November or December, or, as in the cases of Scaleby and Londonderry, in both of these months. The minimum relative humidity occurs in every case between April and September. There are only 2 cases in which it occurs in April, viz. Ilfracombe and Guernsey, and only 1 where it occurs as late as September, viz. Guernsey, which has the same minimum as in April and also in June and August. May would appear to be the most usual month for the minimum except on the east coast. It is, however, difficult to see why the east coast stations without exception should be in this position; and it is noteworthy that with the solitary exceptions of Buxton and Burghill, which have their minima in June, and Ilfracombe and Guernsey, which have theirs in April, June, and August, all the stations which do not have their minima in May have them in July. There are only 5 stations, and they are maritime ones, viz. Scarborough, Lowestoft, Brighton, Ilfracombe, and Guernsey, which have a minimum in August, and in each of these cases there is another and sometimes two minima in the previous months. I should like especially to emphasise the fact that these remarks only apply to the relative humidity at 9 a.m.

Amount of Cloud.

This subject, like relative humidity, is somewhat difficult to discuss, and I cannot help thinking that the amount of cloud must be different at different heights, though, so far as I am aware, there have been no experiments made for the purpose of verifying this conjecture. Possibly the kite experiments recently conducted by Mr. Dines and the ascents of captive balloons, of which we have heard so much, may throw some light on this question, but until we know the results of these experiments we can do but little. Turning now to Table VII. we are struck with a very singular fact. If we first consider the annual column, we shall notice that Londonderry, a maritime station, is the most cloudy station in the kingdom, and the next one is Wakefield, an inland station. If we turn to the minima in the annual column, we find that there are 4 maritime stations, viz. Weymouth, Portsmouth, Ventnor, and Worthing, which form quite a conspicuous group of stations close together, with low readings. If we now turn to the maximum readings, we shall find, as we might expect, that the maximum readings occur, with 4 conspicuous exceptions to be hereafter noticed, in January principally, and then comes November, with a few in December. At some places the maximum occurs twice—for instance, in January and November there are Scarborough, Buxton, Cheadle, and Aspley Guise; Margate has 2, viz. in January and December, and Weymouth 3, in January, November, and December; and it is worthy of note that one moiety of these stations are inland and the other maritime. The 4 conspicuous exceptions are Wakefield, which has its maximum in April, and the 3 Irish stations, of which Londonderry has its maximum in August, and Dublin and Killarney in July. Perhaps in the case of Ireland this may be one of the main reasons why tourists are not so numerous as the Irish desire. With reference to the minimum amount of cloud we shall first note that it occurs between March and

TABLE V.—MEAN TEMPERATURE, 1881–1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.													
Scarborough . .	*38·1*°	38·9°	40·8°	44·5°	49·2°	55·6°	**59·1**°	58·7°	55·4°	48·2°	44·1°	39·2°	47·7°
ENGLAND, E.													
Hillington . .	*36·4*	38·2	40·7	45·7	51·3	57·9	**61·0**	60·0	56·1	48·3	43·0	37·7	48·0
Lowestoft . .	*37·9*	38·7	40·7	44·8	50·1	56·3	**60·1**	**60·1**	57·2	49·8	44·9	39·3	48·3
MIDLAND CO.													
Wakefield . .	*38·0*	38·8	40·6	45·2	50·9	57·1	**59·9**	59·0	55·0	47·5	43·6	38·8	47·9
Hodsock . .	*37·0*	38·6	40·9	45·5	51·0	57·3	**60·3**	59·9	55·3	47·7	43·2	38·0	47·9
Buxton . .	*34·9*	35·9	37·6	42·8	48·3	54·7	**57·3**	56·5	52·8	45·0	40·8	36·0	45·2
Belper . . .	*36·6*	37·9	40·1	45·3	50·7	57·1	**59·7**	58·7	54·6	46·8	42·5	37·6	47·3
Cheadle . .	*36·2*	37·5	39·7	44·6	49·9	56·1	**58·4**	57·7	54·3	46·5	41·9	37·3	46·7
Churchstoke .	*37·1*	38·2	39·9	44·8	49·9	56·4	**58·6**	58·1	54·3	46·7	42·8	38·3	47·1
Burghill . .	*37·9*	39·3	41·7	47·0	52·6	58·8	**61·1**	60·3	56·0	48·0	43·8	38·9	48·8
Ross . . .	*38·2*	39·6	42·0	47·5	53·1	59·4	**62·0**	60·9	56·6	48·3	44·3	39·3	49·3
Cheltenham . .	*37·6*	38·9	40·9	46·2	51·9	58·3	**61·0**	59·9	55·7	47·6	43·8	39·0	48·4
Aspley Guise .	*36·5*	37·9	40·6	45·7	51·3	57·9	**61·0**	60·2	56·0	47·8	42·8	37·6	47·9
ENGLAND, S.													
Regent's Park .	*38·2*	39·4	41·9	47·4	53·6	59·9	**63·1**	62·0	57·8	49·3	44·6	39·5	49·7
Norwood . .	*38·1*	39·5	41·9	47·2	53·1	59·5	**62·6**	61·7	57·6	49·2	44·4	39·4	49·5
Beddington . .	*37·3*	38·8	41·4	46·5	52·6	58·8	**62·2**	61·1	56·8	48·4	43·6	38·4	48·8
Marlborough .	*37·0*	38·3	40·3	45·5	50·9	57·0	**59·7**	58·9	54·8	47·1	42·8	37·9	47·5
Harestock . .	*37·5*	39·0	41·1	46·3	51·7	58·0	**60·9**	60·2	56·5	48·4	43·8	39·0	48·5
Swarraton . .	*37·2*	38·5	40·6	45·9	51·2	57·4	**60·2**	59·6	55·7	47·8	43·4	38·4	48·0
Margate . .	*38·6*	39·7	41·8	46·4	51·9	58·1	**61·9**	61·8	58·5	50·7	45·7	40·4	49·6
Brighton . .	*39·8*	40·7	42·3	47·5	53·4	59·1	**62·2**	62·0	58·9	51·6	47·1	42·0	50·6
Worthing . .	*38·9*	40·1	41·7	47·1	52·7	58·2	61·1	**61·3**	58·3	50·8	46·0	40·7	49·7
Portsmouth . .	*39·3*	40·5	42·5	47·6	53·6	59·6	**62·5**	62·4	58·8	51·0	46·3	41·3	50·4
Ventnor . .	*41·3*	42·0	43·5	48·2	53·4	58·7	61·9	**62·2**	59·6	52·6	48·1	43·4	51·2
Weymouth . .	*41·1*	41·4	42·7	47·4	52·6	58·4	61·3	**61·6**	58·5	51·8	47·4	43·1	50·6
ENGLAND, N.W.													
Scaleby . .	*37·3*	38·2	40·0	45·0	50·3	56·5	**58·5**	58·0	54·2	46·9	42·5	37·9	47·1
Seathwaite . .	*37·8*	38·1	39·5	45·1	50·5	56·9	**58·1**	57·4	54·0	46·8	42·7	38·7	47·1
Macclesfield .	*36·7*	37·9	39·8	45·0	50·3	56·9	**58·9**	58·4	54·5	46·7	42·6	37·8	47·1
Blackpool . .	*38·2*	38·9	40·5	45·5	50·7	56·9	**59·3**	59·0	55·7	48·6	44·2	39·5	48·1
Llandudno . .	*41·1*	41·4	42·4	46·6	51·4	57·4	**59·9**	59·7	56·9	50·2	46·4	42·4	49·6
ENGLAND, S.W.													
Weston-super-Mare	*40·3*	41·1	42·9	47·8	53·1	59·2	**61·6**	**61·6**	58·2	51·0	46·4	41·8	50·4
Ilfracombe . .	*43·1*	*43·1*	44·2	48·2	52·8	58·5	60·8	**61·4**	58·8	52·7	48·9	44·9	51·5
Cullompton . .	*39·3*	40·3	42·2	47·1	52·5	58·3	**60·7**	60·0	56·4	49·0	44·9	40·5	49·3
Ashburton . .	*40·8*	41·6	43·3	47·8	52·8	58·6	**61·2**	60·8	57·7	51·0	46·8	42·4	50·4
Sidmouth . .	*40·6*	41·3	42·5	46·9	51·8	57·5	**60·2**	60·1	57·2	50·6	46·6	42·5	49·8
Falmouth . .	*43·1*	43·4	44·1	48·0	52·4	58·1	**60·6**	**60·6**	57·9	52·0	48·3	45·0	51·1
IRELAND.													
Londonderry .	*39·9*	41·0	42·4	47·0	51·9	57·6	**58·7**	58·3	55·0	48·1	44·1	40·6	48·7
Dublin . .	*41·5*	42·1	43·3	47·5	52·3	58·3	**60·3**	59·5	55·9	49·2	46·0	42·1	49·8
Killarney . .	*41·9*	42·6	43·4	47·1	51·4	56·9	**58·7**	58·6	55·4	49·0	45·8	43·0	49·5
CHANNEL ISLANDS.													
Guernsey . .	*43·2*	43·4	44·8	48·8	53·4	58·4	61·5	**62·0**	60·0	53·6	49·4	45·0	52·0

TABLE VI.—MEAN RELATIVE HUMIDITY AT 9 A.M.—1881-1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.	%	%	%	%	%	%	%	%	%	%	%	%	%
Scarborough	91	88	85	82	79	79	78	78	83	86	89	90	84
ENGLAND, E.													
Hillington	92	89	85	79	76	75	75	78	83	89	92	91	84
Lowestoft	91	88	85	80	78	77	75	75	81	84	89	89	83
MIDLAND CO.													
Wakefield	90	88	86	80	76	76	76	78	82	86	88	89	83
Hodsock	90	88	82	76	71	73	71	75	81	86	90	90	81
Buxton	92	89	86	81	76	75	77	79	82	86	90	91	84
Belper	90	88	85	79	77	77	78	82	86	89	91	89	84
Cheadle	92	90	85	81	76	80	81	82	85	89	93	92	86
Churchstoke	89	88	83	79	74	75	75	79	82	86	88	89	82
Burghill	92	89	83	77	73	71	72	75	82	88	91	91	82
Ross	90	87	80	76	72	73	72	76	81	87	89	88	81
Cheltenham	91	88	83	78	75	76	76	78	84	88	90	89	83
Aspley Guise	93	90	83	75	73	74	71	74	82	87	93	92	82
ENGLAND, S.													
Regent's Park	88	86	82	75	70	71	70	75	80	85	88	87	80
Norwood	90	86	81	74	69	69	68	72	78	85	89	89	79
Beddington	91	87	82	75	70	71	69	74	81	87	90	90	81
Marlborough	93	90	87	79	74	76	75	77	83	88	93	92	84
Harestock	91	88	82	76	71	71	71	74	80	86	90	91	81
Swarraton	...	...	...	...	...	...	...	...	...	...	...	...	...
Margate	91	87	84	79	76	77	74	76	79	83	88	89	82
Brighton	88	86	82	75	72	75	75	72	78	80	86	86	80
Worthing	90	88	83	78	74	76	76	76	80	84	89	89	82
Portsmouth	91	89	83	78	74	74	74	76	80	84	90	90	82
Ventnor	88	86	81	78	76	77	77	77	78	80	85	86	81
Weymouth	88	85	82	79	75	77	76	77	79	81	84	85	81
ENGLAND, N.W.													
Scaleby	90	90	87	81	78	78	81	82	85	90	91	91	85
Seathwaite	85	85	85	78	73	75	77	79	82	83	84	86	81
Macclesfield	91	89	87	82	76	77	79	83	87	89	90	90	85
Blackpool	90	89	85	79	75	75	77	78	82	84	88	90	83
Llandudno	84	82	79	76	72	75	76	76	78	79	82	82	78
ENGLAND, S.W.													
Weston-super-Mare	91	88	85	81	79	80	79	80	84	87	88	90	84
Ilfracombe	87	86	84	83	84	83	84	83	84	85	86	86	85
Cullompton	88	86	80	75	71	71	72	76	81	85	88	89	80
Ashburton	92	87	82	79	75	77	77	79	83	87	90	90	83
Sidmouth	90	88	82	79	77	79	78	79	83	85	89	88	83
Falmouth	88	86	81	77	75	77	78	78	81	83	86	87	81
IRELAND.													
Londonderry	88	88	84	78	73	75	77	81	85	86	89	89	83
Dublin	86	85	81	77	73	74	75	80	84	85	86	86	81
Killarney	90	87	84	80	78	79	82	83	84	87	88	89	84
CHANNEL ISLANDS.													
Guernsey	89	88	86	84	85	84	85	84	84	85	87	88	86

October. In March there are 3 stations with the minimum in that month, viz. Hodsock, Burghill, and Ross, and it is curious to observe that these 3 stations have a second minimum. In April there are 2 stations with the minimum in that month, viz. Seathwaite, which also has a second minimum, and Londonderry, a maritime station. May seems to be the least cloudy month; but it is somewhat singular that though Scarborough has its minimum in this month, the other 3 east coast stations have theirs later. Some of the stations with a minimum in this month have a further minimum, viz. Hodsock, in March, May, and October; Churchstoke, in May and June; Burghill, in May and June; Llandudno, in May and June; Ilfracombe, in May and June; Ashburton, in May and June; Sidmouth, in May and September; and Guernsey, in May and August. In June, besides those stations just mentioned we have Ross and Weymouth, Seathwaite, which has also a minimum in April, and Killarney. In July there are only 2 stations, viz. Norwood, which has also minima in September and October, and Beddington. In August, besides Guernsey we have only Margate, and this is accounted for because July, as a rule, is a wet month. In September we have Hillington and Lowestoft, Aspley Guise, Worthing, and Macclesfield, besides Sidmouth; and in October we have only Dublin, which is somewhat singular, together with Hodsock and Norwood, which have other minima.

Rainfall.

This element of climate has been much studied, but yet it is possible that Table VIII. will provide some room for further consideration. In the annual column we have, of course, Seathwaite, 131·05 ins., more than twice as much as any other station, and then in order come Killarney, 56·60 ins., Ashburton, 50·80 ins., Buxton, 49·17 ins., Falmouth, 42·41 ins., and Londonderry, 40·47 ins. With respect to the stations with the lowest rainfall, we have Aspley Guise with 23·12 ins., Margate with 23·19 ins., Hodsock, 23·78 ins., Norwood, 23·83 ins., and Lowestoft, 23·90 ins. The distribution of these stations is somewhat singular; for though we have, as a rule, a heavier rainfall in the west than in the east, yet the stations seem to blend almost imperceptibly into one another, so that though neighbouring stations may be different, yet this difference is not very marked, and it would almost appear that the situation of the station had as much influence as height above sea-level, and the western district. It is a curious feature in rainfall research, that though many organisations have come into existence for the investigation of rainfall problems in the various parts of the country, very little systematic discussion of the records thus obtained has been made.

If we now turn to the maximum rainfall, we have 5 stations with the maximum in August, viz. Cheadle, Scaleby, Macclesfield, Blackpool, and Dublin. Of these stations the first 4 lie between 53° and 55° N. lat., and between 2° and 3° W. long. With respect to Dublin, I can only imagine that its position, as what we may term, of typical town station, may have something to do with it. In September, which may be described as a fairly dry month, there is no maximum rainfall. October, as we all know, is a wet month, and in it a great many maxima occur, and it is noteworthy that, with the exceptions of Weymouth, Blackpool, Sidmouth,

TABLE VII.—MEAN AMOUNT OF CLOUD (0–10) AT 9 A.M.—1881–1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.													
Scarborough .	6·9	6·8	6·3	6·4	6·0	6·2	6·2	6·4	6·2	6·4	6·9	6·7	6·5
ENGLAND, E.													
Hillington . .	7·8	7·4	7·1	7·1	6·9	7·0	6·9	6·5	6·4	7·0	7·7	7·7	7·1
Lowestoft . .	7·2	7·1	6·6	6·8	6·3	6·6	6·5	6·5	6·1	6·5	7·4	7·1	6·7
MIDLAND CO.													
Wakefield . .	7·8	7·9	7·5	8·0	7·1	7·4	7·3	7·3	7·5	7·5	7·9	7·7	7·6
Hodsock . .	7·2	7·1	6·6	7·1	6·6	7·0	7·0	6·9	6·7	6·6	7·3	7·0	6·9
Buxton . .	7·9	7·7	6·9	7·1	6·6	6·7	7·0	7·1	7·0	7·1	7·9	7·7	7·2
Belper . .	...	...	...	...	...	...	...	...	...	...	...	...	...
Cheadle . .	7·5	7·2	6·7	6·8	6·5	6·7	7·0	7·3	6·7	6·6	7·5	7·3	7·0
Churchstoke .	7·8	7·7	7·4	7·3	7·1	7·1	7·6	7·4	7·4	7·7	8·2	7·6	7·5
Burghill . .	7·4	7·2	6·4	6·8	6·4	6·4	6·8	6·6	6·6	6·9	7·3	7·1	6·8
Ross . . .	6·9	6·5	5·8	6·3	6·0	5·8	6·2	6·1	6·1	6·4	6·8	6·7	6·3
Cheltenham .	7·5	7·2	6·7	6·8	6·3	6·4	6·8	6·7	6·7	6·9	7·2	7·3	6·9
Aspley Guise .	7·3	7·2	6·6	6·9	6·6	6·8	6·8	6·7	6·4	6·6	7·3	7·1	6·9
ENGLAND, S.													
Regent's Park .	...	...	...	...	...	...	...	...	...	...	...	...	...
Norwood . .	7·9	7·4	6·5	6·6	6·4	6·5	6·3	6·4	6·3	6·3	7·5	7·4	6·8
Beddington . .	7·9	7·7	6·9	7·0	6·5	6·6	6·3	6·4	6·6	6·9	7·7	7·5	7·0
Marlborough .	8·0	7·4	6·5	7·2	6·2	6·6	6·6	6·8	6·8	6·5	7·4	7·8	7·0
Harestock . .	7·7	7·4	6·7	6·8	6·2	6·6	6·6	6·3	6·4	6·5	7·4	7·5	6·8
Swarraton . .	7·8	7·6	6·9	7·0	6·4	6·7	6·8	6·6	6·6	6·7	7·6	7·6	7·0
Margate . .	7·7	7·5	6·5	6·5	6·4	6·6	6·4	6·2	6·3	7·0	7·5	7·7	6·9
Brighton . .	...	...	...	...	...	...	...	...	...	...	...	...	...
Worthing . .	7·0	6·5	6·0	6·0	5·6	5·9	6·0	5·5	5·4	5·8	6·8	6·7	6·1
Portsmouth . .	7·0	6·5	5·7	5·6	5·0	5·4	5·6	5·1	5·4	5·7	6·8	6·9	5·9
Ventnor . .	6·7	6·6	5·7	5·6	5·3	5·5	5·8	5·6	5·6	6·0	6·6	6·5	6·0
Weymouth . .	6·7	6·2	5·5	5·5	4·9	4·8	5·3	5·0	5·2	5·7	6·7	6·7	5·7
ENGLAND, N.W.													
Scaleby . .	7·7	7·5	7·0	6·7	6·5	6·6	7·3	7·3	6·8	6·8	7·5	7·4	7·1
Seathwaite . .	7·9	7·2	7·2	6·9	7·0	6·9	7·7	7·6	7·3	7·8	8·0	7·7	7·4
Macclesfield .	7·1	6·8	6·7	6·5	6·4	6·3	6·9	7·0	6·1	6·8	7·3	7·4	6·8
Blackpool . .	7·2	6·7	6·1	6·0	5·3	5·5	5·8	6·2	6·2	6·7	7·2	7·5	6·4
Llandudno . .	6·7	6·6	6·3	5·9	5·6	5·6	6·5	6·8	6·3	6·5	6·9	6·6	6·4
ENGLAND, S.W.													
Weston-super-Mare	7·8	7·2	6·5	6·5	6·0	6·3	6·5	6·4	6·5	6·8	7·7	7·6	6·8
Ilfracombe . .	7·7	7·0	6·4	6·2	5·7	5·7	6·5	6·4	6·4	6·9	7·8	7·7	6·7
Cullompton . .	7·6	7·1	6·4	6·3	5·9	6·0	6·6	6·3	6·4	6·7	7·4	7·4	6·7
Ashburton . .	7·0	7·0	6·1	6·1	5·8	5·8	5·9	5·9	5·9	6·4	6·9	7·1	6·3
Sidmouth . .	7·6	7·4	6·8	6·6	6·1	6·3	6·7	6·6	6·1	6·8	7·5	7·5	6·8
Falmouth . .	7·4	6·9	6·6	6·4	5·9	6·1	6·6	6·4	6·3	6·8	7·1	7·3	6·7
IRELAND.													
Londonderry .	7·9	7·8	7·5	7·3	7·4	7·7	8·2	8·4	7·6	7·7	7·8	8·1	7·8
Dublin . .	6·6	6·9	6·2	6·3	6·1	6·2	7·0	6·5	6·0	5·9	6·3	6·4	6·4
Killarney . .	7·4	7·6	7·0	7·0	7·0	6·9	7·8	7·5	7·0	7·0	7·3	7·5	7·3
CHANNEL ISLANDS.													
Guernsey . .	7·4	7·0	6·4	6·1	5·7	5·8	5·8	5·7	6·1	6·5	7·3	7·3	6·4

TABLE VIII.—MEAN RAINFALL, 1881-1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Scarborough . .	2·16	1·81	1·86	*1·72*	1·89	1·93	2·58	2·89	2·04	**3·52**	2·39	2·23	27·02
ENGLAND, E.													
Hillington . .	2·17	1·68	1·78	*1·50*	1·78	2·12	2·77	2·89	2·42	**3·20**	2·57	2·36	27·24
Lowestoft . .	1·64	*1·38*	1·44	1·49	1·62	1·79	2·54	2·32	2·16	**3·10**	2·38	2·04	23·90
MIDLAND CO.													
Wakefield . .	2·00	1·83	*1·78*	1·86	1·92	2·23	2·71	2·49	1·83	**3·08**	2·10	2·24	26·07
Hodsock . .	1·86	1·63	*1·56*	1·60	2·13	2·05	2·29	2·25	1·68	**2·74**	1·96	2·03	23·78
Buxton . .	4·66	3·65	3·81	*2·75*	3·14	3·37	3·97	4·48	3·84	5·17	4·75	**5·58**	49·17
Belper . . .	2·74	2·26	2·12	*2·02*	2·29	2·60	2·63	2·87	2·33	**3·32**	2·90	3·09	31·17
Cheadle . .	2·64	2·07	2·09	*1·96*	2·18	2·77	2·79	**3·21**	2·63	3·13	2·90	3·02	31·39
Churchstoke . .	2·74	2·34	*1·92*	1·95	2·44	2·16	2·11	2·62	2·30	**3·40**	3·11	3·19	30·28
Burghill . .	2·15	1·94	*1·47*	1·59	2·09	1·98	2·17	2·22	1·82	**2·59**	2·54	2·38	24·94
Ross . . .	2·57	2·12	*1·77*	1·84	2·21	2·11	2·47	2·45	2·21	**3·14**	2·83	2·59	28·31
Cheltenham . .	2·07	2·06	1·71	*1·70*	1·93	1·96	2·38	2·55	2·12	**2·73**	2·72	2·46	26·39
Aspley Guise .	1·73	1·48	1·40	*1·39*	1·96	1·65	2·26	2·32	1·90	**2·62**	2·40	2·01	23·12
ENGLAND, S.													
Regent's Park .	1·88	1·75	1·68	*1·53*	1·73	1·78	2·38	2·26	2·13	**2·87**	2·46	2·12	24·57
Norwood . .	1·73	1·67	1·56	*1·46*	1·64	1·82	2·52	2·18	1·95	**2·78**	2·51	2·01	23·83
Beddington . .	1·81	1·72	1·66	*1·43*	1·68	1·65	2·48	2·02	2·00	**2·85**	2·73	2·16	24·19
Marlborough .	2·51	2·38	2·08	1·87	*1·85*	2·24	2·52	2·62	2·36	3·29	**3·40**	2·99	30·11
Harestock . .	2·77	2·23	2·18	*1·80*	1·90	1·98	2·39	2·68	2·49	3·51	**3·64**	3·20	30·77
Swarraton . .	2·56	2·32	2·07	*1·68*	1·92	1·91	2·48	2·58	2·45	**3·52**	3·44	3·00	29·93
Margate . .	1·75	1·51	1·46	*1·30*	1·55	1·63	2·12	2·03	2·09	**3·06**	2·49	2·20	23·19
Brighton . .	2·51	2·01	1·83	1·57	*1·51*	1·71	2·30	2·13	2·58	**3·83**	3·20	2·72	27·90
Worthing . .	2·28	1·91	1·67	*1·42*	1·45	1·64	2·25	1·96	2·46	**3·48**	3·19	2·46	26·17
Portsmouth . .	2·34	1·97	1·69	*1·47*	1·54	1·69	2·31	2·11	2·44	**3·32**	3·31	2·46	26·65
Ventnor . .	2·60	2·05	1·77	*1·59*	1·63	1·78	2·22	1·83	2·60	**3·75**	3·40	2·87	28·09
Weymouth . .	2·41	2·03	1·82	1·67	*1·55*	1·91	1·91	1·89	2·24	3·08	**3·47**	3·10	27·08
ENGLAND, N.W.													
Scaleby . .	2·43	2·02	2·18	*1·74*	2·16	2·64	3·49	**4·13**	3·15	3·21	3·09	3·02	33·26
Seathwaite . .	13·19	11·20	10·51	6·78	7·39	*6·47*	9·34	11·68	12·45	12·16	14·11	**15·77**	131·05
Macclesfield .	2·71	2·11	2·40	*1·96*	2·36	3·02	3·22	**3·73**	2·83	3·54	2·96	3·40	34·24
Blackpool . .	2·75	2·17	2·26	*1·83*	2·23	2·15	2·93	**3·80**	3·23	3·77	3·59	3·17	33·88
Llandudno . .	2·51	1·91	1·95	*1·82*	1·98	1·94	2·28	2·92	2·46	**3·84**	3·07	2·86	29·54
ENGLAND, S.W.													
Weston-super-Mare	2·28	1·89	*1·63*	1·73	1·83	1·89	2·49	3·14	2·58	**3·49**	2·91	2·76	28·62
Ilfracombe . .	3·31	2·77	2·49	2·08	2·12	*1·96*	2·77	3·59	3·43	**4·67**	4·52	4·64	38·35
Cullompton . .	3·11	2·74	2·29	2·20	2·12	*1·98*	2·97	3·00	2·59	3·84	3·82	**3·89**	34·55
Ashburton . .	5·14	4·51	3·96	2·94	2·60	*2·51*	3·17	3·61	3·40	5·91	6·26	**6·79**	50·80
Sidmouth . .	2·91	2·44	2·17	2·10	*1·79*	2·01	2·60	2·84	2·40	3·39	**3·53**	3·40	31·58
Falmouth . .	4·15	3·49	2·94	2·46	*2·08*	2·16	2·88	3·18	3·25	4·82	5·22	**5·78**	42·41
IRELAND.													
Londonderry .	3·59	2·97	2·94	*2·20*	2·62	2·78	3·41	4·05	3·58	4·10	4·02	**4·21**	40·47
Dublin . .	2·22	1·92	*1·81*	1·91	2·09	1·88	2·65	**3·16**	1·97	2·71	2·85	2·21	27·38
Killarney . .	6·31	5·31	4·08	3·36	3·06	*2·92*	3·52	4·77	3·91	5·65	6·29	**7·42**	56·60
CHANNEL ISLANDS.													
Guernsey . .	2·88	2·30	1·98	1·94	1·85	*1·83*	2·06	2·27	2·80	**4·19**	4·17	3·71	31·98

Falmouth, and the 3 Irish stations, the maximum of all the maritime stations occurs then. If now we consider November, we see how few maxima there are: only 4,—2 inland stations and 2 maritime stations,—and it is curious to observe that the maritime stations of Weymouth and Sidmouth, and the inland stations of Marlborough and Harestock, are not far distant from one another respectively. There are 7 stations with their maxima in December, and which are all situate in the west, with the single exception of the high-level station at Buxton. It is particularly noteworthy that there are no maximum rainfalls in either July or September. If we now turn to the minimum rainfall, we shall find that it is spread over five months, as against four for the maximum, and that these five months occur in the first half of the year, whilst the four months of the maximum are in the latter half. There is no minimum rainfall in January, and only one in February, viz. the maritime station of Lowestoft. With respect to March, there are 7 stations which have their minima then, viz. Wakefield and Hodsock, on the low ground; Churchstoke, Burghill, and Ross, on ground of moderate elevation, and the maritime stations of Weston-super-Mare and Dublin. This is curious; and it will be noticed that the stations in the midland counties form two groups, and why these two groups should be associated with the distant maritime stations of Weston-super-Mare and Dublin I cannot conceive. April appears to be the most usual month for the minimum, a fact which is rather opposed to the old adage about "April showers," though in accordance with it if the showers are of brief duration. In May we have 5 minima, viz. the inland station of Marlborough, and the 4 maritime stations on the south coast, viz. Brighton, Weymouth, Sidmouth, and Falmouth. It is difficult to understand why Brighton should be included, and not Worthing, Portsmouth, and Ventnor, and also why Marlborough should be included, though possibly this may be due to its somewhat high elevation. June has 6 minima, viz. Scathwaite in the north-west, Ilfracombe, Cullompton, and Ashburton in the south-west, and Killarney and Guernsey, and it will be noticed that all these stations, with the exception of Guernsey, are westerly ones.

With respect to the number of rainy days (Table IX.), if we turn to the annual column we shall at once notice that Londonderry has the greatest number, 243, and Weymouth the smallest, 153 (90 days less), and we shall also notice that, as a rule, the western stations, with the solitary exception of Weston-super-Mare, have more rainy days than the eastern stations. December seems to have the greatest number of maxima, and if this column be examined we shall note that it comprises nearly all the western stations. Another fact we shall observe is that a great many stations, viz. 19, have two or more maxima. It will also be noticed that these maxima are in four months, October, November, December, and January. The number of maxima in October and November is 12, a somewhat singular fact, and one rather opposed to the Rainfall Table VIII., where we saw that, as a rule, October had the heaviest rainfall. The number of maxima in January is 17, amongst which are many maritime stations. With respect to the minimum number of rainy days, we shall find that the month of June has the largest number, viz. 36 out of 40 stations, and that the 4 exceptions are all maritime stations, viz. Brighton, Portsmouth, Weymouth, and Llandudno, all of which have their minimum

TABLE IX.—No. of Rainy Days (0·01 In. and upwards)—1881–1900.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Scarborough	18	14	16	14	15	13	14	15	14	19	19	17	188
England, E.													
Hillington	19	16	15	14	14	13	14	15	13	20	19	19	191
Lowestoft	18	13	14	13	12	11	14	14	13	18	16	16	172
Midland Co.													
Wakefield	16	13	13	13	12	11	13	15	13	15	16	15	165
Hodsock	18	14	14	14	13	13	14	15	14	17	17	17	180
Buxton	19	17	17	15	15	14	16	17	16	19	19	18	202
Belper	18	14	14	14	14	12	14	16	14	18	17	17	182
Cheadle	19	15	16	13	14	13	15	17	14	18	18	18	190
Churchstoke	17	13	15	13	15	12	15	15	15	18	17	17	182
Burghill	17	12	13	14	12	12	14	14	13	16	17	18	172
Ross	17	14	14	15	14	14	16	16	16	18	18	17	189
Cheltenham	18	15	14	14	13	13	15	15	14	19	18	18	186
Aspley Guise	16	12	13	12	13	11	13	15	12	17	15	17	166
England, S.													
Regent's Park	16	13	12	13	12	11	13	13	12	15	15	15	160
Norwood	16	14	13	13	13	11	14	14	13	16	17	17	171
Beddington	16	13	12	12	12	11	12	14	13	15	16	16	162
Marlborough	18	14	14	14	14	13	15	15	13	18	18	19	185
Harestock	17	14	13	13	12	12	14	14	13	17	16	18	173
Swarraton	16	12	13	12	11	11	13	14	13	16	16	18	165
Margate	18	13	14	13	12	9	13	13	13	17	17	17	169
Brighton	17	13	13	12	10	11	11	13	12	16	17	16	161
Worthing	16	13	11	12	10	10	11	12	12	16	16	16	155
Portsmouth	16	13	13	13	10	11	13	13	13	16	17	17	165
Ventnor	16	12	13	12	11	11	11	13	12	16	17	16	160
Weymouth	15	11	13	11	10	11	11	12	12	14	16	17	153
England, N.W.													
Scaleby	19	16	17	14	15	14	17	19	18	18	20	19	206
Seathwaite	20	17	19	15	16	15	19	20	19	18	20	21	219
Macclesfield	18	15	15	13	14	13	17	17	16	17	17	18	190
Blackpool	19	15	15	14	13	13	14	17	15	18	18	19	190
Llandudno	17	15	14	13	12	13	14	15	16	18	17	18	182
England, S.W.													
Weston-super-Mare	17	12	12	12	13	11	14	15	14	15	16	17	168
Ilfracombe	18	13	15	13	14	11	15	16	15	18	17	18	183
Cullompton	19	15	14	14	12	11	15	16	15	19	19	20	189
Ashburton	18	14	14	13	13	11	15	15	15	18	19	20	185
Sidmouth	19	16	15	15	13	13	16	18	15	19	19	20	198
Falmouth	21	15	15	15	12	12	15	15	15	20	20	22	197
Ireland.													
Londonderry	23	19	21	17	17	17	21	22	19	22	22	23	243
Dublin	19	16	15	15	15	15	16	18	15	16	18	18	196
Killarney	21	18	17	17	17	15	19	20	17	20	21	22	224
Channel Islands.													
Guernsey	19	14	15	13	11	10	11	12	14	19	20	20	178

TABLE X.—CORRECTIONS TO BE ADDED TO THE TEMPERATURE OBSERVATIONS TO REDUCE THE SAME TO SEA-LEVEL.

Station.	Correction.	Station.	Correction.
ENGLAND, N.E.		*Worthing*	+0·1
Scarborough	+0·5	Portsmouth	0·1
		Ventnor	0·3
ENGLAND, E.		Weymouth	0·3
Hillington	0·3	ENGLAND, N.W.	
Lowestoft	0·3		
MIDLAND COUNTIES.		Scaleby	0·4
		Seathwaite	1·6
Wakefield	0·4	Macclesfield	1·9
Hodsock	0·2	Blackpool	0·2
Buxton	3·3	*Llandudno*	0·3
Belper	1·3		
Cheadle	2·4	ENGLAND, S.W.	
Churchstoke	2·0	Weston-super-Mare . .	0·1
Burghill	1·0	Ilfracombe	0·1
Ross	0·8	Cullompton	0·7
Cheltenham	0·7	Ashburton	2·2
Aspley Guise	1·5	Sidmouth	0·6
ENGLAND, S.		Falmouth	0·7
Regent's Park	0·5	IRELAND.	
Norwood	0·7		
Beddington	0·4	*Londonderry* . . .	0·2
Marlborough	1·7	*Dublin*	0·2
Harestock	1·1	*Killarney*	0·3
Swarraton	1·1		
Margate	0·3	CHANNEL ISLANDS.	
Brighton	+0·1	Guernsey	+0·7

in May. Many stations have two or more minima. The minima all occur in seven months, namely, February, March, April, May, June, July, and September.

In concluding the remarks on this table, I should like to say that the difference in the number of rainy days at any station is small, being not more at any station than 10 days between the maximum and minimum, and that the great differences in the annual column between the different stations have arisen because at some stations the number of rainy days per month is greater than at others.

In conclusion, I should like to congratulate the Society on the body of hard-working and trustworthy observers which has been got together; and with respect to the observers, I should like to assure them of the keen appreciation of their voluntary labours which the Society feels, and how much it regrets that the want of observations in the unrepresented parts of the kingdom does not enable me to delineate those climatic lines of equal value with the accuracy that this fine set of observations, extending over so many years, requires.

DISCUSSION.

The President (Mr. W. H. Dines) said that the Fellows were greatly indebted to Mr. Bayard for his admirable paper. The working up of so many observations meant the expenditure of much time and trouble.

Mr. W. Marriott wished to express his thanks to Mr. Bayard for the time and energy which he had devoted to the working up of the climatological data contained in *The Meteorological Record*. He had on two previous occasions given discussions of the observations for the 10 years 1881-1890 and for 1891-1900; but the present paper was still more valuable, as it dealt with the 20 years 1881-1900. It was remarkable to find that there were so many as forty stations which had continued during the 20 years. This showed great devotion to the work on the part of the observers. He had been interested in the various remarks made by Mr. Bayard, but he thought that most of the points referred to could be explained if they were discussed in connection with the distribution of atmospheric pressure and the direction of the prevailing winds.

Mr. Marriott then exhibited a series of maps showing the range of temperature, relative humidity, amount of cloud, and number of rainy days at the various stations given in the tables of Mr. Bayard's paper. These were compiled by taking the difference between the highest monthly values, as printed in the thick type, and the lowest values, as printed in italic type. Thus the annual range of the various elements was brought out in a very decided manner. These maps showed clearly that there was a much greater range of temperature at inland stations than at coast stations. The influence of the warm water of the Atlantic was distinctly manifest in the small range of temperature at the south-western coast stations, and also in the very small range in the values of relative humidity. One of the most striking features brought out in these maps was the small range in the monthly amounts of cloud and in the number of rainy days over the central northern parts of the country, while along the south and west coast there was a considerable variation in these elements. These facts were fully supported by the registered amounts of sunshine from a considerable number of stations which were exhibited on another map. These figures showed the great prevalence of sunshine at the maritime stations, especially along the south coast, and the least amount over the central northern parts of the country.

Dr. C. Theodore Williams remarked that the conclusions arrived at in the paper were instructive, but unfortunately not quite so definite as might be wished. He could clearly trace the influence of the Gulf Stream in the maps exhibited by Mr. Marriott. He hoped some day that more definite information would be extracted from these observations. He thought the Society was to be congratulated on its excellent body of observers.

Mr. J. Hopkinson said that the paper was one which scarcely lent itself to discussion, being a record of facts about which there could be no dispute. He thought that this was the first attempt to work up thoroughly reliable, consecutive, and contemporaneous observations on our climate for so long a period as 20 years, and that the Society was to be congratulated on being the recipient of the results of Mr. Bayard's labours in his three papers on "English Climatology."

Mr. R. H. Curtis remarked that suggestions had been made in the paper to account for phenomena to which attention had been specially called, which in some cases seemed to be scarcely adequate explanations. For example, he knew of no headland at Falmouth which would be at all likely to affect in the way suggested the temperature recorded at the Falmouth Observatory; nor was he aware of any reason for suspecting the existence of a "cool current" between the mainland and the Isle of Wight competent to influence the mean temperature of Portsmouth. The exact time at which the temperature in its diurnal

march attains the mean for the day can only be ascertained from hourly observations of that element, such as those published by the Meteorological Office for their observatories, and from those it may be seen that the time at which the mean is reached depends primarily upon the season of the year, but also to some extent upon the position and the character of the physical surroundings of the place of observation. At Kew in May it is reached at 8·30 a.m., and again at about 8·30 in the evening, whilst in January it is not reached till after 10 a.m., and in the evening at 8 p.m. But at Aberdeen in May the mean for the day is reached at about 7 a.m., whilst in January it is not attained until 10·30 a.m. ; and as such an annual variation exists, it would seem that a comparison of the mean *yearly* temperatures with the mean at 9 a.m. could not be of much practical use. Another criticism he would offer was as to the value of comparisons of the annual means of relative humidity at stations widely apart and very differently situated. A better plan, he thought, would have been to examine the progress of the means throughout the year at individual stations representative of different districts, or of different classes of stations. In this way the fact to which Mr. Aldridge and the late Dr. Tripe called attention would again be brought out, that in winter certain parts of the coast have a drier climate than some inland stations. He could not follow the author in his conclusion as to the amount of cloud at different heights, nor did he know why January should be expected to be more cloudy than any other month ; but it was easy to understand why Wakefield should be so much more cloudy than other stations in the list, seeing that it is the only manufacturing town of importance which it comprises.

Mr. R. Inwards said he quite agreed in expressing gratitude to Mr. Bayard for his labours in compiling the paper, but he thought it a great pity that so much time and trouble should have been spent on work which was based on only one observation each day. He hoped that in the near future it would be possible to obtain, by comparing the diagrams of self-recording instruments, something like a real average, including every hour of every day.

Mr. F. J. Brodie, referring to Mr. Hopkinson's remarks, said that 10 years ago the Meteorological Office published a similar set of means for 20 years, and quite recently had brought out another set for a 30-year period. He thought the stations of the Meteorological Office were rather better distributed than those dealt with in the present paper. For instance, Mr. Bayard drew attention to Lowestoft as being the place having the smallest rainfall, whereas the district round Shoeburyness was supposed to be the driest part of England.

Sur.-Maj. W. G. Black suggested that the paper would have been more complete had wind, storms, snow, and days of frost been included in the tables.

Mr. J. Hunter, speaking as an observer at Belper of over 20 years' standing, stated that he and his sister had been in the habit of taking 9 p.m. observations as well as those of afternoon. The afternoon ones had not yet been tabulated, but he hoped to be able to tabulate them when an opportunity occurred. The results of his observations showed that the 9 p.m. readings were so close to those of 9 a.m. that he had often thought it not worth while to take the trouble to observe them. The mean temperature for 9 a.m. and 9 p.m. for the 20 years was 46°·6, while the mean temperature for 9 a.m. alone was 46°·7, a difference of but 0°·1. He could not blame observers for not taking evening readings. He had also taken the temperature of the river Derwent on six mornings out of seven in each week, and had found that on the yearly mean the river temperature was 2°·6 higher than the air temperature. He could not help thinking that the position of the screens at the various stations might account for many of the small differences enumerated by Mr. Bayard, and that the most convenient position did not always mean the best one. He thought that a period of 20 years for rainfall means was hardly long enough, as during such a

short time great variations might occur. At Belper for the 10 years 1877-1886 the mean annual rainfall was 35·63 ins. ; during the next 10 years, 1887-1896, 28·55 ins.; while the mean for the 20 years 1881-1900 was 31·17 ins., and for the 25 years 1877-1901, 32·04 ins. The 4 years 1877-1880, which were not included in the present table, were wet years. Throughout the series, 1882 was the wettest year at Belper with 42·90 ins., and 1887 was driest with only 20·23 ins.

Dr. H. R. MILL said that, in considering the period of average monthly maximum or minimum, it might perhaps be pointed out that when the difference between two consecutive months is very small—and anything under a quarter of a degree of temperature or a tenth of an inch of rain is practical equality—it may indicate merely that the turning-point of the curve was reached near the end of the earlier month, so that one month contained the rising and the other the falling part of the curve. With regard to rain, it was to be feared that the irregularities noted by Mr. Bayard arose from the fact that 20 years is too short a period to eliminate accidental variations due to heavy falls. While 30 years have been shown by Dr. Hann to give a satisfactory average for annual fall, he, Dr. Mill, was of opinion that perhaps 50 years are necessary to give an equally satisfactory monthly curve. As regards the distribution of rainfall over the country, he thought it would be straining the data unduly to attempt, from the small number of stations under consideration, to deduce the laws of geographical distribution; but it might fairly be expected that the stations would fall into their natural places in an orderly system depending on exposure to wind, configuration and height of land. This work of Mr. Bayard's struck him as of real importance, as it supplied a set of clearly arranged tables which are sure to be in continual demand by those wishing to obtain data from observations conscientiously taken by competent observers using accurate instruments. The only regret is that the number of stations is yet so small. It is often difficult to induce observers to maintain continuity for long periods, yet such continuity is absolutely essential in order to obtain climatological data which can be trusted to represent the normal conditions of the country. Mr. Marriott's discussion of the range of the various conditions was peculiarly interesting, as it brought out very clearly the contrast between seaside and inland localities.

Mr. F. C. BAYARD, in reply, said that the means published by the Meteorological Office, referred to by Mr. Brodie, were not all for the same period, and therefore not strictly comparable with each other, while those in the present paper were all for the same 20 years, and from observations taken under precisely the same conditions, the stations being inspected every two or three years. He was glad to hear Mr. Hunter's remarks as to 9 p.m. observations.

The Bora in the Adriatic.—Lieut. Kessler, of Pola, read a paper before the meteorological section of the Karlsbad Congress on the Bora in the Adriatic, and its relation to the weather conditions. He distinguished two main types of Bora, anticyclonic and cyclonic. The former is characterised by the occurrence of strong squalls on the eastern coasts and littoral, with clear dry weather and moderate cold ; the cyclonic Bora is much stronger and steadier, is not restricted to the eastern coast, but often extends as far as the coast of Italy, and is usually accompanied by overcast rainy weather, with snow and intense cold in winter. Greater certainty in forecasting the Bora is expected as the result of scientific balloon ascents which have recently been carried out with increasing interest.—*Geographical Journal*, December 1902.

Temperature of the British Islands.—The Meteorological Council have published a Supplement to the *Temperature Tables for the British Islands.* The Tables give the monthly means of the daily maximum and minimum readings for 117 places in the British Islands for the 30-year period 1871-1900. The Supplement contains "Difference Tables for each five years for the extrapolation of mean values."

The accompanying table of mean temperatures for each year of the period 1871-1900 for the several districts of the British Islands is also given; the highest values are printed in thick type, and the lowest in italic type.

MEAN ANNUAL TEMPERATURES, 1871-1900.

YEARS.	Scotland, N.	Scotland, E.	Scotland, W.	England, N.E.	England, N.W.	England, E.	Midland Counties.	England, S.	England, S.W.	Ireland, N.	Ireland, S.	Channel Islands.
	°	°	°	°	°	°	°	°	°	°	°	°
1871 . .	46·1	46·9	47·6	46·6	48·0	47·5	48·3	48·4	50·7	48·6	50·0	...
1872 . .	46·4	47·1	48·6	47·9	49·5	49·6	49·6	50·3	**51·5**	48·4	49·9	...
1873 . .	46·1	46·9	48·1	47·3	48·4	47·9	48·3	48·9	50·4	48·2	49·6	...
1874 . .	46·5	47·0	47·9	47·5	48·6	48·4	48·9	49·5	51·4	48·5	51·1	...
1875 . .	46·6	47·4	48·2	47·7	48·6	48·4	48·7	49·2	50·6	48·3	51·0	...
1876 . .	46·3	46·9	48·0	48·0	48·8	49·2	48·9	49·9	51·1	48·1	50·8	...
1877 . .	45·2	46·2	47·4	47·0	48·2	48·7	48·7	49·5	51·2	47·6	50·5	...
1878 . .	46·0	47·2	48·6	47·9	49·2	48·9	49·3	50·1	50·9	49·0	50·6	52·1
1879 . .	*43·8*	*44·1*	*45·6*	*45·0*	*45·9*	*45·8*	*45·8*	*46·9*	48·4	*46·1*	*48·3*	*49·6*
1880 . .	45·8	47·0	48·2	47·7	48·6	48·8	48·4	50·0	51·2	48·6	50·3	51·5
1881 . .	44·1	45·4	46·3	46·2	47·3	47·7	47·4	49·1	49·4	47·4	49·0	51·8
1882 . .	46·2	47·3	48·2	48·4	49·0	49·1	48·7	50·4	50·3	48·7	49·8	51·7
1883 . .	45·3	46·9	47·6	47·4	48·3	48·5	48·2	49·7	49·6	48·0	49·4	51·5
1884 . .	46·6	**47·7**	48·6	48·7	49·3	49·8	49·5	51·0	50·7	48·8	50·2	52·5
1885 . .	44·4	45·9	46·4	46·8	46·9	47·5	47·3	49·0	48·7	47·2	48·6	50·7
1886 . .	44·3	45·6	46·3	46·4	47·1	47·5	47·4	49·0	48·8	47·0	48·7	51·2
1887 . .	45·0	46·2	46·8	46·6	47·3	47·1	47·0	48·1	48·6	48·0	49·2	50·9
1888 . .	44·4	45·1	46·7	46·1	47·1	47·0	46·7	48·2	*48·3*	47·5	48·9	50·8
1889 . .	46·1	46·6	48·0	47·4	48·3	47·9	48·0	49·5	49·4	48·5	49·8	51·9
1890 . .	46·0	46·6	47·7	47·6	48·1	47·7	47·5	49·1	49·2	48·4	49·7	51·3
1891 . .	45·5	45·7	47·3	46·5	47·8	47·5	47·2	48·9	48·8	47·8	49·0	51·3
1892 . .	43·9	44·2	45·9	45·7	46·8	46·8	46·3	48·4	48·4	47·0	48·5	51·4
1893 . .	46·7	47·3	48·9	48·7	**50·3**	49·6	**49·8**	51·2	51·4	**49·8**	51·2	53·9
1894 . .	46·5	46·2	48·0	47·6	49·3	48·8	48·6	50·4	50·1	48·5	50·0	52·7
1895 . .	45·0	45·1	46·7	47·0	47·7	47·8	47·4	49·1	49·0	47·3	48·8	51·8
1896 . .	46·4	46·9	48·3	48·1	49·2	48·7	48·5	50·3	50·3	48·7	50·3	52·9
1897 . .	45·8	46·1	48·0	47·9	49·1	48·9	48·7	50·9	50·7	48·4	50·5	53·2
1898 . .	**46·9**	**47·7**	**49·2**	**49·2**	50·2	**50·0**	49·7	**51·6**	51·4	49·7	**51·5**	53·9
1899 . .	46·5	46·6	48·3	48·3	49·5	49·6	49·2	51·4	51·4	49·3	51·2	**54·3**
1900 . .	45·9	46·1	47·8	48·2	48·9	49·5	48·9	50·6	50·2	48·4	49·8	53·4

THE RAINFALL OF DOMINICA.

By C. V. BELLAMY, F.R.Met.Soc., M.Inst.C.E., F.G.S.

(Plate I.)

[Read November 19, 1902.]

THE following remarks and the accompanying tables should be taken as an Appendix to the Paper[1] on "The Rainfall of Dominica" which was read before the Society on May 19, 1897.

During the discussion which followed the reading of the original paper, the hope was expressed that further statements might be collected and in due course laid before the Society; and encouraged by the remarks which fell from the late Mr. G. J. Symons, the necessary data were collected, the results of which are now subjoined.

It is regretted that the interval between the publication of the original paper and the submission of the appendix has been so great, but the removal of the author to Cyprus naturally interfered with the preparation of these tables and somewhat broke the thread of the story.

So far as records go, however, the delay is not of much consequence so long as they are made as complete as possible, and it is considered that in this respect the information on the subject of the Dominica Rainfall is as full as careful research can make it.

TABLE I.—MONTHLY RAINFALL IN DOMINICA, 1897.

No. on Map.*	Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
		ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1	Batalie . .	0·37	0·55	3·38	0·88	20·14	7·89	9·55	7·02	5·35	7·01	4·73	10·78	77·65
2	Bath . .	2·76	2·06	3·19	1·15	13·74	6·34	8·23	9·03	3·90	6·96	9·05	10·10	76·51
3	Botanical Station	2·60	3·21	3·36	1·39	12·75	6.50	8·80	8·87	4·51	8·42	7·81	10·55	78·77
4	Castle Bruce .	12·89	7·48	14·45	4·55	35·55	9·14	11·46	7·22	8·83	9·97	23·99	19·68	165·21
5	Geneva . .					No Returns								...
6	Goodwill . .	2·90	2·86	...	...	12·58	4·76	8·86	9·06	3·54	7·42	7·37	8·88	68·23
7	Gov. Ho., Roseau	2·30	2·93	3·41	1·23	11·75	6·14	10·42	7·29	4·31	8·02	7·01	9·26	74·07
8	Hampstead .	5·62	3·40	10·97	5·70	21·57	8·28	11·11	7·81	4·15	12·85	14·85	21·63	127·94
9	Hatton Hall .	6·23	7·58	14·33	1·69	13·56	9·74	13·10	13·17	8·51	6·98	9·71	10·99	115·59
10	Hillsborough .	1·85	3·47	4·14	1·39	17·52	7·34	12·36	9·98	4·11	7·12	9·70	15·87	94·85
11	La Haut . .	4·03	4·03	5·03	1·43	21·70	10·35	11·09	9·49	7·00	13·08	8·37	13·20	108·80
12	Londonderry .	6·08	7·05	9·21	0·89	30·11	6·01	12·02	5·49	7·54	13·54	9·04	15·33	122·31
13	Macoucherie .					No Returns								...
14	Malgretout .	4·40	6·80	6·04	4·04	25·23	12·35	9·50	13·00	6·37	10·00	12·55	12·50	122·78
15	Melville Hall .	5·11	6·69	11·52	2·69	39·05	8·58	11·45	8·26	9·49	13·07	11·43	16·30	143·64
16	Point Mulatre .	7·93	7·44	11·83	2·42	23·54	10·20	11·34	12·54	9·09	10·76	22·26	16·30	145·65
17	Portsmouth .	4·30	6·16	10·69	2·64	19·37	7·65	12·07	10·63	6·19	5·31	8·03	15·75	108·79
18	Rosalie . .	12·10	6·81	16·52	4·43	45·74	10·31	10·80	10·23	6·17	14·60	20·14	20·75	178·60
19	St. Aroment .	3·89	5·12	5·39	1·37	12·66	8·70	11·98	9·71	5·85	8·70	9·83	10·95	94·15
20	St. Sauveur .	13·34	5·02	14·98	6·96	39·51	9·70	11·38	12·24	...	16·36	...	13·86	Incomp.
21	Shawford . .	8·38	9·51	10·30	3·36	33·18	16·54	20·85	22·53	10·72	11·37	16·74	17·98	181·46
22	Soufrière . .	4·70	4·02	6·52	1·87	20·98	9·31	8·05	12·48	6·96	16·23	12·92	10·64	114·68
23	Stowe . .					No Returns								...
24	Sugar Loaf .					No Returns								...
25	Training School					No Returns								...
26	Wall House .	2·82	1·66	2·68	1·40	16·66	8·01	9·61	7·64	5·85	8·30	5·83	9·90	80·36
27	Woodford Hill .	5·37	2·69	9·86	0·60	32·14	5·09	7·86	7·96	8·76	15·31	16·61	19·10	131·35

* These Nos. are those given on the Map in the former paper, which is reproduced in Plate I.

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxiii. p. 261.

The following is an explanation of the information now placed before the Society:—

Table I. contains a statement of the monthly rainfall at 22 stations for the year 1897, out of the 27 dealt with in the original paper, and the results show that the records for that year were, generally speaking, below those of the preceding year of 1896. This was due to the unusual fall recorded during the month of November in the latter year, as alluded to already in the original paper, and it may not be out of place to record here the occurrence of a most remarkable and, for the place alluded to, unprecedented fall in the neighbouring Island of Montserrat during the same month.

It was the author's privilege to visit that island, in a professional capacity, in the early part of 1897, and in the course of his investigations it was ascertained that the amount of rainfall recorded annually there was as follows:—

1892	50·56 ins.	1895	73·20 ins.
1893	71·31 ,,	1896	94·56 ,,
1894	47·01 ,,		

For the last two years mentioned the figures are taken from the records kept at Elburton Estate, where for the twelve years ending 1895 the mean annual fall was 59·29 ins., so that that recorded for 1896 was no less than 35·27 ins. above the mean of the preceding twelve years.

For the month of November at the same place and for the same period the mean was 7·28 ins., but for the same month of the year 1896 the fall was 36·04 ins.

The following are copies of the notes taken at the time:—

"On the morning of Sunday, November 29, at 9 a.m., a fall of 20·13 ins. was recorded as having fallen since 9 a.m. on the previous day."

. . . .

"The weather during the greater part of Saturday the 28th is described as showery, only light rains and nothing extraordinary having fallen up to about 10 p.m. At this hour the deluge appears to have commenced . . . but the heaviest of the rain had ceased by 4 o'clock in the morning, only comparatively light rain having fallen after that hour."

. . . .

"It may be assumed, therefore, that the downpour was confined to six or eight hours at the outside."

This was a most remarkable fall of rain, and although nothing recorded in Dominica approaches this figure, yet it is safe to say that what occurred in Montserrat might also occur in Dominica, more especially as the cause is considered to have been cyclonic. It is to be remarked also that scarcely had Montserrat recovered from the effects of this disastrous flood than it was devastated by the terrible hurricane during the summer of 1899.

The other Tables Nos. II. to VI. refer to the following stations, namely:—

Londonderry,	from 1874 to 1881,	mean rainfall . . .	105·46 ins.
Rosalie,	,, 1889 to 1897,	,, . . .	147·04 ,,
Shawford,	,, 1875 to 1897,	,, . . .	184·57 ,,
Soufrière,	,, 1887 to 1897,	,, . . .	100·90 ,,
Wall House,	,, 1881 to 1897,	,, . . .	90·36 ,,

TABLE II.—Monthly Rainfall for Londonderry Estate, 1874-1881.

Month.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	4·37	7·11	6·66	4·53	4·30	5·08	21·29	2·58
February . . .	4·70	4·10	1·86	5·83	2·84	4·67	2·11	3·40
March	7·12	3·74	2·14	4·88	11·66	14·74	2·68	3·65
April	3·70	1·95	8·14	7·91	8·10	7·40	3·64	7·58
May	4·91	2·79	15·06	7·14	10·48	9·26	9·60	11·34
June	3·62	5·59	15·22	14·43	7·10	11·06	9·36	21·29
July	16·45	7·97	12·96	16·33	14·40	8·29	14·60	7·29
August	19·30	10·97	4·20	5·10	7·56	10·11	15·11	12·10
September . . .	10·35	6·23	5·85	6·61	5·95	12·10	8·84	14·33
October	8·15	8·01	6·64	10·23	15·10	10·69	8·13	5·40
November . . .	17·67	7·08	3·51	13·92	11·18	39·68	7·11	14·02
December . . .	6·30	16·31	8·29	12·00	5·39	5·22	5·57	4·34
Year	106·64	81·85	90·53	108·91	104·06	136·30	108·04	107·32

TABLE III.—Annual Rainfall at Rosalie Estate from 1889 to 1897.

		ins.			ins.
1889	Rainfall . . .	60·79	1894	Rainfall . . .	111·03
1890	,, . . .	127·73	1895	,, . . .	168·22
1891	,, . . .	156·16	1896	,, . . .	202·07
1892	,, . . .	151·35	1897	,, . . .	180·60
1893	,, . . .	165·47			
				Mean for 9 years .	147·04

TABLE IV.—Annual Rainfall at Shawford Estate from 1875 to 1897.

		ins.			ins.
1875	Rainfall . . .	176·25	1887	Rainfall . . .	164·36
1876	,, . . .	167·06	1888	,, . . .	193·60
1877	,, . . .	163·46	1889	,, . . .	229·58
1878	,, . . .	146·77	1890	,, . . .	179·97
1879	,, . . .	205·60	1891	,, . . .	189·45
1880	,, . . .	214·64	1892	,, . . .	166·91
1881	,, . . .	187·44	1893	,, . . .	209·72
1882	,, . . .	159·04	1894	,, . . .	149·86
1883	,, . . .	222·05	1895	,, . . .	234·67
1884	,, . . .	168·54	1896	,, . . .	190·80
1885	,, . . .	135·80	1897	,, . . .	181·46
1886	,, . . .	208·19			
				Mean for 23 years .	184·57

TABLE V.—Monthly Rainfall for Soufrière Estate, 1887-1897.

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January .	4·88	4·12	1·32	19·46	3·80	5·48	4·24	7·62	6·19	6·23	4·70
February.	4·65	2·51	3·41	4·06	5·26	2·73	9·16	3·58	2·38	1·68	4·02
March .	·91	4·46	1·21	4·99	·55	5·71	4·44	6·92	5·01	2·00	6·52
April . .	2·24	5·59	4·81	7·45	3·30	2·30	4·28	4·31	9·63	3·83	1·87
May . .	8·07	9·60	15·06	8·90	9·87	11·55	10·27	4·06	19·34	7·56	20·98
June . .	11·99	16·98	32·70	3·13	9·63	10·71	14·99	8·11	3·58	8·03	9·31
July . .	7·22	10·93	18·28	7·40	15·84	12·00	16·79	7·12	6·42	12·06	8·05
August .	13·39	7·91	5·79	10·09	11·98	7·14	10·94	4·64	11·96	9·31	12·48
September	6·39	12·44	10·92	3·63	5·76	10·17	14·45	9·14	21·28	10·83	6·96
October .	7·84	13·64	8·43	11·42	12·47	15·31	10·81	10·91	13·87	8·42	16·23
November	5·12	2·80	6·92	4·22	23·42	6·23	4·46	8·90	8·37	19·69	12·92
December	3·64	9·59	6·47	8·21	5·85	4·83	8·18	4·66	8·90	9·64	10·64
Year . .	76·34	100·57	115·32	92·96	107·73	94·16	113·01	79·97	116·93	98·28	114·68

Besides these, Tables VII., IX., and X. accompanying the original paper give the records for St. Aroment, Woodford Hill, and Geneva, up to the year 1896; in the first two the records for the year 1897 must be included; in the case of the last-named station there were no returns for the year 1897.

The means, therefore, for all stations, so far as the records collected go, may reasonably be put down as in the following Table:—

AVERAGE YEARLY RAINFALL.

No. on Map.	Station.	Period.		Rainfall. ins.
1.	Batalie	5 years,	1893 to 1897	69·91
2.	Bath	5 ,,	,,	84·89
3.	Botanical Station	5 ,,	,,	85·81
4.	Castle Bruce	5 ,,	,,	162·67
5.	Geneva	14 ,,	1883 to 1896	122·64
6.	Goodwill	3 ,,	1893, 1896 and 1897	70·56
7.	Government House, Roseau	4 ,,	1893 to 1897	81·48
8.	Hampstead	5 ,,	1893 to 1897	110·67
9.	Hatton Hall	4 ,,	1894 to 1897	113·99
10.	Hillsborough	4 ,,	,,	84·36
11.	La Haut	2 ,,	1896 and 1897	102·85
12.	Londonderry	9 ,,	1874 to 1881 and 1897	107·33
13.	Macoucherie	2 ,,	1893 and 1894	70·78
14.	Malgretout	5 ,,	1893 to 1897	133·18
15.	Melville Hall	5 ,,	,,	125·60
16.	Point Mulatre	5 ,,	,,	142·56
17.	Portsmouth	2 ,,	1894 and 1897	99·74
18.	Rosalie	9 ,,	1889 to 1897	147·04
19.	St. Aroment	22 ,,	1876 to 1897	104·59
20.	St. Sauveur	3 ,,	1894 to 1896	160·05
21.	Shawford	23 ,,	1875 to 1897	184·57
22.	Soufrière	11 ,,	1887 to 1897	100·90
23.	Stowe	no returns		
24.	Sugar Loaf	,,		
25.	Training School	2 years,	1894 and 1895	84·83
26.	Wall House	16 ,,	1881 to 1897	90·36
27.	Woodford Hill	17 ,,	1880 to 1897	106·75
	Mean Annual Rainfall for the Island			109·87

According to the foregoing data the mean annual rainfall for the whole Island of Dominica may therefore be put down at 109·87 ins. In Table VI. of the original paper the figure was 110·67 ins., arrived at from the records kept at five selected or representative stations. By taking the means of all stations from which records are procurable, as in the foregoing table, the difference is found to be ·95 in. less than the former figure; this is not great.

TABLE VI.—ANNUAL RAINFALL AT WALL HOUSE ESTATE FROM 1881 TO 1897.

		ins.			ins.
1881	Rainfall	100·83	1890	Rainfall	85·70
1882	..	72·41	1891	..	70·88
1883	..	112·94	1892	..	116·53
1884	..	80·99	1893	..	89·87
1885	..	64·98	1894	..	109·44
1886	..	107·78	1895	..	82·87
1887	..	76·85	1896	..	122·20
1888	..	No return.	1897	..	80·36
1889	..	71·14			
				Mean for 16 years	90·36

The observations recorded at Government House, Roseau, give results shown on Table VII. accompanying this paper, from which it will be seen that the total rainfall for the year 1897 was below the average of the four preceding years by 7·41 ins. January, April, June, and September were considerably below the mean, the last one particularly so. On the other hand, May was a particularly wet month, and December was much above the average. Rain was recorded on 221 days in 1897, as against 199 days in the previous year; the mean daily rainfall for this period, *i.e.* 221 days, was ·335 in., and the mean daily fall for the entire year of 365 days, ·203 in. This rate was below that of the previous year, although rain fell on 22 days more.

TABLE VII.—MONTHLY RAINFALL AT GOVERNMENT HOUSE, ROSEAU, FOR 1897.

MONTH.	No. of Days on which Rain fell.	Total Rainfall.	Mean for 4 Preceding Years.
		ins.	ins.
January	12	2·30	5·77
February	15	2·93	3·16
March	16	3·41	3·33
April	6	1·23	2·36
May	21	11·75	5·22
June	19	6·14	7·93
July	27	10·42	10·41
August	22	7·29	8·22
September	19	4·31	10·17
October	20	8·02	9·16
November	26	7·01	9·46
December	18	9·26	6·29
Total	221	74·07	81·48

TABLE VIII.—TEMPERATURE RECORDED AT ROSEAU FOR 1897.

MONTH.	Highest.	Lowest.	Mean.
January	88°	70°	79°
February	84	70	77
March	85	71	78
April	92	72	82
May	88	72	80
June	86	73	79·5
July	91	73	82
August	91	73	82
September	92	74	83
October	92	73	82·5
November	90	71	80·5
December	89	70	79·5
Mean	89	72	80

Table VIII. shows the results of observations on temperature recorded at Government House, Roseau, for the year 1897, from which it will be seen that the month of February, with a maximum of 84° and a minimum of 70°, was the coolest, and that of September, with a maximum of 92° and a minimum of 74°, was the hottest, the mean being 77° for the former and 83° for the latter.

The highest reading for the year was 92° and the lowest 70°, the mean monthly temperature being 80°.

The range of temperature is not wide. February is the coolest month and September the hottest. High readings were recorded in the month of April; but the minimum readings are perhaps the best guide, and indicate a gradual rise of temperature from March to September, and a much more rapid fall from the latter month to December.

A comparison between rainfall and temperature may be arrived at by reference to the preceding table of rainfall.

In January the temperature was normal, and the rainfall very much below the average. February was a cool month, and the rainfall was a little below the average. In March both temperature and rainfall were normal; but in April the conditions were rather remarkable. On the 17th the temperature recorded was 84°, on the 18th it rose to 91°, and on

the 19th to 92°, as high as that recorded in the hottest part of the year. On the 20th the temperature fell to 84° again. The rainfall for the 18th was ·13 in., and for the 19th ·20 in., but for the whole month it was only 1·23 ins., or little more than half the mean rainfall for the same month during the preceding four years. May was the wettest month of the year, but the temperature was not remarkable. In June both the temperature and the rainfall were below those of the previous month, and the latter nearly 2 ins. below the mean for that month. In July the rainfall corresponded with the mean, and the temperature was normal. August, September, and October, the hottest months of the year, as shown by the minimum readings, produced rainfall much below the average. In November the temperature was normal, but the rainfall was below the mean. In December the temperature was normal, but the rainfall was high.

The foregoing notes, though brief, will, it is hoped, prove serviceable for the purposes of record, and may be found a useful guide to the climate of the Island of Dominica.

DISCUSSION.

The President (Mr. W. H. Dines) said that the stations could not very well be compared with each other, as the observations were mostly for different periods. It was, however, better to have these observations than nothing at all, as they gave some guide to the rainfall of the island.

Mr. R. H. Curtis remarked that the paper emphasised what Dr. Mill had said on Mr. Bayard's paper, with regard to the necessity of having a series of observations covering a period sufficiently long to give reliable mean results, a condition more applicable to rainfall observations than to those of any other meteorological element. Especially was this the case in dealing with the climate of a mountainous island such as Dominica, in which the rainfall at the same station might range in different years from 60·8 ins. to 202·1 ins.; and where, in the same year, the fall at one station might amount to only 68·23 ins., whilst at another it would reach 181·46 ins. But it was seldom possible to get for such places complete data, and the Society was much indebted to Mr. Bellamy for collecting and tabulating those contained in this and in his preceding paper, which gave at least an approximate view of the rainfall of the island.

NOTES ON THE CLIMATE OF CYPRUS.

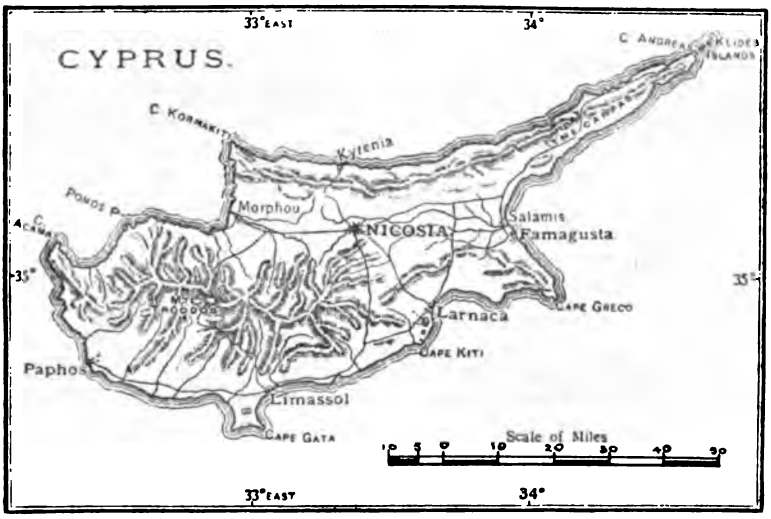
By C. V. BELLAMY, F.R.Met.Soc., M.Inst.C.E., F.G.S.

[Read December 17, 1902.]

Introductory.

CYPRUS is an island lying towards the extreme eastern end of the Mediterranean Sea between long. 32° 20′ and 34° 35′ E., and lat. 34° 33′ and 35° 41′ N. It is distant about 60 miles from the coast of Caramania or Anatolia in Asia Minor, and about 40 miles from that of Syria. It covers an area of 3584 square miles, corresponding in extent to the three counties of Sussex, Kent, and Surrey together.

Its physical features are rather remarkable. It is divided through the centre by the Central plains, which run east and west, and are alluded to as the Messaoria on the east, the Nicosia in the centre, and the



Morphou plain on the west. They extend from the shore of the Famagusta Bay on the east to that of Morphou on the west, over a length of about 60 miles. To the northward these plains are bounded by the precipitous crags of the Kyrenia Mountains, which extend from near Cape Kormakiti on the west for upwards of 70 miles in an easterly and east-north-easterly direction to the Carpas, the name given to that remarkable promontory at the north-easterly extremity of the Island.

These mountains reach altitudes of 3106 ft. at Kornos Vouno at the western end, 3085 ft. at Trypa Vouno, 3135 ft. at Buffavento, 2405 ft. at Pentadactylos, 2431 ft. at Olymbos, and 2380 ft. at Sina Oros. They are only broken by two important passes, one at St. Catharine's, through which the public road from Nicosia to Kyrenia is carried, and the other at a point about 25 miles to the east between Lefkonico and Akanthou.

The southern and south-western portion of the Island is covered by the Troödos Mountains, the most prominent of which is Mount Troödos or "Chionistra," rising to a height of 6406 ft. The other prominent peaks are Khorteri, 4255 ft.; Kykkou Vouno, 4315 ft.; Adelphi, 5303 ft.; Papoutsa, 5124 ft.; and Kionia or Makhera, 4674 ft. The foot-hills of this range extend as far east as the neighbourhood of Larnaca, near to which place the mountain of Santa Croce or Stavro Vouni rises abruptly to an altitude of 2260 ft., and constitutes a conspicuous feature of the landscape for many miles around; and in a westerly direction they do not terminate until close to the sea towards Ktima, and the Akamas in the Paphos district.

These mountain ranges have, without doubt, a considerable influence upon the temperature of the central plains, and more especially the climate of Nicosia, with which this paper more particularly deals; for while they moderate both the force and temperature of the cold winds during winter blowing off the snowclad mountains of the Taurus range in Asia Minor, they also exclude the cool sea-breezes which might temper the excessive heats of summer.

The central plains reach their greatest altitude in the neighbourhood of Nicosia, which is about 500 ft. above the sea, from which point the land falls with a certain regularity towards the sea-shore on the east and west. For about eight months in the year, during which the rainfall is inappreciable, this tract of country is a dry, treeless expanse, almost destitute of verdure, and capable of supporting only coarse thorn-bushes and thistles, squills and asphodel, which thrive in abundance; but during the winter season the face of Nature undergoes a complete change, and from the first fall of the winter rain in October or November the land commences to assume its covering of verdure, which, as time goes on and the season's rains foster it, develops into waving cornfields of barley, wheat, or oats, interspersed with a profusion of flowers called into existence by the warm sunshine and the approach of spring. Beautiful in the extreme as is this season of the flowers, it is but brief, and heralds the approach of summer, and the ripening of the crops, which begin to silver in the months of March and April, and are ready for the sickle usually in the month of May. Then once more the land resumes its arid appearance, and induces the belief that it is incapable of supporting anything so valuable as a cereal crop. The clouds depart, and verily the skies become as brass; and until the return of seed-time strong hot winds and dust-storms prevail, with scarcely any intermission save an occasional thunderstorm.

The hill-country, however, offers a welcome contrast to the plains, and is well clothed, though by no means densely, except in the Carpas, with foliage; and where the depredations of the native or the ravages of forest fires have permitted, heavy timber abounds. The most conspicuous among the trees are the *Pinus Halepensis* and the *P. Pinaster*, which for the most part constitute the forests of Cyprus. The *P. Laricio*, found almost exclusively on Troödos, develops considerable proportions, and is a particularly handsome tree. The undergrowth is made up of Ilex, Arbutus, and varieties of the Juniper. The other principal trees are the Plane, Alder, Oak, Cypress, Pistacia, Sumac, all of which grow wild. Among the cultivated trees the principal are the Walnut, Olive,

and the Caroub or Locust-bean Tree, whose product is largely exported for use in the manufacture of cattle foods, etc. The vine flourishes in all parts of the Island, and is largely cultivated in the higher altitudes of the south-central part of the Island for the manufacture of wine.

Most, if not all, of these trees possess the virtue of being able to withstand the heat and drought of the summer months, while the pines are further subjected to an intensity of cold, and otherwise to a combination of circumstances under which many members of the vegetable kingdom would succumb.

The country throughout is seamed by numerous water-courses, but perennial streams are confined to the mountainous region, and do not extend to the plains, where the rivers only run water during or immediately after a fall of rain. The longest river-bed—it would, perhaps, be incorrect to describe it as the largest river—is the Pedias, which takes its source in the neighbourhood of the Monastery of Makhera, among hills which reach altitudes of over 4000 ft., whence it descends to the plains, passing close to the capital town of Nicosia, meandering through the plain of the Messaoria till it emerges on the sea-shore near the ruins of the ancient city of Salamis situated on the Bay of Famagusta. The river next in importance is the Yalias or Idalia, which also rises in the same neighbourhood, and not a mile from the source of the Pedias. It debouches on the plains shortly before reaching the ancient Idalion, now known as Dali, traverses the Messaoria in a direction more or less parallel with the Pedias, and discharges into the sea at almost the same place as that river.

As a general rule, such perennial streams as exist have their origin in springs which issue at high altitudes in the mountains; they descend and run water until the plains are encountered, when they sink below the surface and become lost in the gravels which form the river-beds. In these well-watered valleys through which they pass vegetation is fairly luxuriant, cultivation is carried on throughout the year, and one is reminded of the highly poetic phrase of Holy Writ—"a land of rivers of waters, of corn, of wine, and of oil," since all these three important commodities are produced in such neighbourhoods, and amid such surroundings.

That the water disappears below the surface is a wise provision of Nature, since it feeds the subterranean sources of supply from which the villages in the plains derive their water. Flowing over the surface in the river-beds, water would be exposed, on the one hand, to evaporation, and, on the other, to contamination; but there is in most localities abundance of water to be found at depths varying from 30 to 60 ft. below the surface, clear, cool, and usually fairly pure. Thus, for instance, the town of Nicosia, containing some 14,000 inhabitants, depends for its supply upon two systems or chains of wells sunk in the valley of the Pedias river at a distance of less than 2 miles from the city walls; while all the other towns of Cyprus are supplied in a similar manner.

Among the springs the most conspicuous is that issuing at Kythrea, about 8 miles from Nicosia, the yield of which is about three million gallons per diem, according to the season. The whole of this range, the Kyrenia Mountains, consisting of limestone, yields a considerable quantity of water at a number of springs throughout its entire length, but that alluded to is by far the largest in the whole of Cyprus.

Numerous springs issue also from the Troödos Mountains, and especially from the central mass now known as Olympus or Khionistra, yielding from 100,000 to 200,000 gallons in 24 hours individually; and from such or similar sources the Island, either directly or indirectly, is able to support life during the long period which characterises the summer of Cyprus. In spite of the paucity of rainfall, of the long summer, and of the intense dryness of the air, there are sufficient sources of water which, if properly regulated, could be made to suffice for the wants of far more than the present population of the Island, and would serve to convert what is for the greater part of the year a desert, into a smiling landscape, clothed in verdure from year's end to year's end.

Records and Instruments.

The records with which this paper deals mainly are the results of readings taken at the observatory connected with the Public Works Department of Cyprus. The station is at Nicosia, situated at an altitude of 536 ft. above mean sea-level, but the barometer is kept in the offices adjoining at an altitude of 522·83 ft. The latitude of the station is 35° 9′ 20″ N., and the longitude 33° 21′ 55″ E.

The observatory was established in August 1899, and consisted originally of a barometer, maximum thermometer, minimum thermometer, hygrometer, rain-gauge, anemometer, and wind-vane.

The first five instruments composed a set with which the observatory started. Excellent as these instruments are, it is not to be expected that they are so reliable as instruments which have been examined and certified at Kew, but careful readings and regular observations have resulted in records from which a very close approximation of the climatic conditions of the neighbourhood can be arrived at. The readings have been taken throughout at 9 a.m. and at 3 p.m., local time.

In November 1900, a Fortin barometer was obtained, certified at Kew; also a solar radiation thermometer with exposed bulb, a similar instrument *in vacuo*, and a terrestrial radiation thermometer were added. Recently, also, further improvements and additions have been made by the acquisition of new maximum, minimum, solar, and terrestrial radiation thermometers, hygrometers, an evaporation gauge, and an anemometer, all certified at Kew. The station is now fairly well equipped.

A station has also recently been established in connection with the Irrigation Works at Akhyritou, near Famagusta, and another is about to be opened at Limassol, which latter, it is hoped, will be placed in daily telegraphic communication with the Meteorological Department of the Government of Egypt.

While it is acknowledged that the deductions arrived at in this paper depend on records of instruments that do not pretend to absolute accuracy, it has been thought that such information will prove of use for reference, and it will not be out of place to give the results so far obtained before dealing with those records, which are now being kept with instruments of greater precision. From the present date therefore, a fair start will be made.

The period covered by the observations dealt with in this paper

commences with the winter season of 1899-1900, and closes with that of 1901-2. It includes, therefore, three winters and two summers, and the means of both seasons are ascertained from this number.

It is to be noted that the calendar year has for the most part been ignored, for the reason that it is considered that such division of time bears no practical relationship to what may be described as the "meteorological year." The solar year is divided into two well-defined parts, that during which the sun's rays fall vertically on the north side of the equator, and the other south of the same. The equinoxes being the periods at which the weather may be expected to, and usually does, undergo a change, should constitute the commencement or close of the two principal seasons of the year. Spring and autumn are merely periods of transition from the coldest or wettest to the driest or hottest season; the solstices do not mark a change in the weather and they seldom herald one, for as a general rule the highest temperature is recorded some weeks after what is described by long usage "midsummer's day," and likewise the worst or most inclement or coldest period of the year is that which is usually recorded long after the winter solstice.

For convenience, however, the winter season has in the accompanying observations been made to commence on October 1, and the summer on April 1. The practical results are that better gradients are obtained and more intelligible diagrams are produced. Until meteorological science has advanced sufficiently far to divide the year into periods more compatible with the changes in the weather, perhaps the first day of the month nearest to the equinox of that period will answer present purposes.

Air Pressure.

The principal features are the wide range of high and low readings during the winter seasons, and the narrower limits within which the summer readings are confined. The highest mean reading is in the month of December, and the lowest in that of July. The extreme highest reading was 30·56 ins. at 9 a.m. on January 6, 1900. It was followed by a fall of the temperature.

The extreme lowest reading was recorded on March 12, 1902, at 3 p.m. This was followed by high winds on the 13th, and a heavy fall of snow on the mountain ranges of Kyrenia and Troödos; but the amount of rain collected on the following morning at Nicosia was only 0·11 in., on the 14th 0·09 in., and on the 15th 0·17 in. Low temperatures, however, immediately followed, due most probably to the heavy snow on the surrounding hills.

It is not easy to predict the consequences of a movement in the barometer. As a general rule a fall portends high winds rather than rain. The cause of a fall makes itself apparent within the subsequent 6 or 12 hours, and unless rain intervenes before the expiration of this period, a gale is almost certain to be the result. For the summer months, a high barometer followed by a sudden or rapid fall predicts strong hot winds which intervene within 12 hours usually, from the commencement of the fall of the mercury. Nevertheless, it has been observed that a rapid fall is marked, not infrequently, by seismic disturbances, and this was specially the case on January 17, 1902. At 3 p.m.

on the 16th the reading of the barometer was 29·610 ins.; at 9 a.m. on the 17th it was 29·458 ins.; at 3 p.m. on the same day it had gone down to 29·420 ins.; but by 9 a.m. on the 18th it had risen to 29·648 ins.; at 12.9 p.m. on the 17th, three smart shocks of earthquake were felt.

Similarly, on the night of January 5, 1900, a smart shock of earthquake occurred, sufficiently severe to alarm many of the inhabitants of Nicosia and other parts of Cyprus, and doing slight damage to a number of buildings, one of which, an old Mosque, had to be demolished as the immediate result of this occurrence. It was accompanied by a low barometer.

The relationship between atmospheric pressure and volcanic activity has frequently come under the consideration of the author, who lived for some time in the island of Dominica, within fifty miles of the scene of the recent appalling disaster at Martinique, which forms a link in the chain of the Lesser Antilles, each of which has its dormant volcano or Soufrière, and all are subject to occasional earthquake shocks. It was there observed that a low barometer was almost invariably accompanied by increased activity in the Soufrières and a greater volume of sulphurous gases given off. Seismologists will be able to explain the coincidence, no doubt; but that there is a coincidence, and a very striking one, is beyond question in the author's mind.

Temperature.

At Nicosia the month of January is considerably the coldest of the year, while the hottest is that of July, though it is approached fairly closely by that of August.

The mean temperature for the year is 67°·2. The extreme maximum was 108° and extreme minimum 28°, showing the rather remarkable range of 80°. This is probably an unusual figure.

Troödos is the sanitarium and summer resort of Cyprus, whither the Headquarters' Staff and Military go during the hottest part of the summer. The settlement is at an altitude of rather over 5000 ft. above sea-level, and the observations were recorded at an altitude of 5500 ft. The season there opens in June and closes in October, and a comparison of the readings show that by this means the excessive heat of Nicosia is avoided. Thus, while the highest mean maximum temperature in Nicosia reaches 106°·5, the temperature at Troödos during the summer of 1901 did not at any time exceed 85°. As a matter of fact, during the summer of that year the thermometer rose on two occasions in Nicosia to 108°; and while the mean temperature at Nicosia for July was 82°·5, at Troödos it was only 71°·5. The difference of 11° is just that required to make life bearable.

It was not possible to obtain detailed readings at Troödos for the whole year, because the settlement is uninhabited for seven months of the year; but during the last winter the extreme lowest temperature was ascertained by the simple expedient of leaving a self-recording minimum thermometer secured under the eaves of a house, exposed to the wind but sheltered from the sun. The instrument was fixed up in the month of October 1900 and was read on March 16, 1901, for the first time after the winter. The index then showed an extreme minimum

temperature of 14°. There had been a somewhat heavy fall of snow on the previous day, and there was from 6 to 9 ins. then lying on the ground. At the time of observation, 2.30 p.m., the temperature was 34°; and at 5.30 p.m. it had fallen to 27°. The temperature in the screen at Nicosia at 3 p.m. on the same day was 50°.

A study of the relative temperatures of the two places for the months during which observations were kept at Troödos gives the following results:—

MEAN TEMPERATURE.

1901.	Nicosia.	Troödos.	Difference.
	°	°	°
June	77·2	61·7	15·5
July	83·7	71·7	12·0
August	83·3	68·2	15·1
September	78·8	61·6	17·2

The extreme lowest temperature in Nicosia so far recorded is 28°, that at Troödos 14°; the extreme highest recorded at the former is 108°, and at the latter 85°; difference 23°.

The thermometer at Troödos was again read on May 30, 1902, when the lowest reading between March 17 and that date was shown to have been 17°·5. On the same day, May 30, the following temperatures were recorded:—at 7 a.m 66°, at 2 p.m. 65°, and at 5 p.m. 60°.

On the following night the temperature fell to 49°, and at 6 a.m. on the 31st it stood at 60°. The readings in Nicosia for these days were:—

30th, 9 a.m., 72°	3 p.m. 79°	Maximum 82°	Minimum 52°
31st, ,, 74°	,, 79°	,, 82°	,, 54°

Between March 17 and May 30 the lowest temperature recorded in Nicosia was 41° on March 20.

Humidity.

At certain seasons of the year there are wide differences between the dry and wet-bulb readings. For instance, on July 6, 1901, at 3 p.m. the dry-bulb stood at 105° and the wet-bulb at 75°. This is the greatest difference recorded. On June 23, 1900, the dry-bulb reading was 94° and the wet 68°, difference 26°. On August 4, 1901, the dry-bulb stood at 106° and the wet at 81°, difference 25°.

Radiation.

The highest solar radiation reading *in vacuo* was 173°, recorded on September 11, 1901, and the lowest 67° on December 27, 1900. The exposed bulb gave the highest reading, 121°, on August 5, 1901, and the lowest, 48°, on January 17, 1901. The terrestrial radiation thermometer gave the highest reading, 68°, on July 5 and 7, 1901, and the lowest reading, 25°, on January 21, 1901, and January 25, 1902.

In a country like Cyprus, where all atmospheric moisture is of the highest importance, some means require to be devised for gauging the quantity of dew distilled in relation to terrestrial radiation readings. It is recorded, for instance, on July 5, 1901, that the terrestrial radiation reading was 68°. At 9 a.m. the same morning the hygrometric readings were:—Dry-bulb 93°, wet-bulb 84°, dew-point 78°·5, elastic force ·974 in., and relative humidity 63%. It would be interesting to know what was the amount of dew which fell during the previous night, and what

was the practical result of this fall. There are no means, so far as the author is aware, of ascertaining this information without automatic or self-recording instruments yet to be invented.

The paucity of rain in Cyprus is certainly not compensated for by atmospheric humidity, as in some countries, and for considerable periods of the spring of the year the cereal crops must, it is believed, subsist mainly, if not wholly, upon the dew distilling each night. The important question, therefore, which invites solution is, assuming that rainfall be taken as a unit of measurement, what relation does the dew-point bear to rainfall? And how can the maximum dew-point be gauged without automatic instruments?

Rainfall.

The following is a statement of rainfall recorded at the Public Works Observatory at Nicosia during the period under review:—

Month.	Total.	No. of Rainy Days.	Greatest Fall.	Date.	Month.	Total.	No. of Rainy Days.	Greatest Fall.	Date.
1899.	ins.		ins.		1900.	ins.		ins.	
October .	0·51	3	0·27	10th	April . .	...	...	...	...
November .	2·14	10	0·58	22nd	May . .	1·36	3	0·86	8th
December .	3·41	8	2·15	12th	June . .	0·60	1	0·60	3rd
1900.					July . .	0·30	1	0·30	5th
January .	2·88	8	0·72	28th	August .	...	...	...	...
February .	2·76	13	0·74	21st	September .	...	...	...	...
March .	0·71	7	0·26	16th					
Total Winter Season.	12·41	49	...	...	Total Summer Season.	2·26	5	...	...
					Total for 12 Months.	14·67	54	...	...

Month.	Total.	No. of Rainy Days.	Greatest Fall.	Date.	Month.	Total.	No. of Rainy Days.	Greatest Fall.	Date.
1900.					1901.				
October .	0·58	4	0·32	14th	April . .	...	...	...	...
November .	1·05	5	0·30	29th	May . .	3·77	6	0·88	22nd
December .	5·67	11	1·37	26th	June . .	0·05	1	0·05	12th
1901.					July . .	0·25	2	0·20	10th
January .	2·05	8	0·98	16th	August .	...	...	...	...
February .	0·34	3	0·26	28th	September .	0·25	2	0·23	10th
March .	0·26	3	0·23	6th					
Total Winter Season.	9·95	34	...	...	Total Summer Season.	4·32	11	...	...
					Total for 12 Months.	14·27	45	...	...

Month.	Total.	No. of Rainy Days.	Greatest Fall.	Date.
1901.	ins.		ins.	
October. . . .	0·29	4	0·15	11th
November . . .	0·67	3	0·33	5th
December . . .	0·22	5	0·08	1st & 8th
1902.				
January. . . .	1·78	6	0·91	6th
February . . .	1·13	6	0·47	27th
March	1·61	12	0·78	26th
Total Winter Season .	5·70	36	...	...

One reason for adopting what may be termed the "equinoctial year" has already been given, but there are still stronger reasons for this course in dealing with the rainfall of Cyprus, because the rain which falls between the months of October and March, inclusive, is relied upon for the cultivation of the staple products of the island, namely, the cereals. Unless copious rain falls in the months of October and November, the ploughing and seed-time for barley are delayed, and the prospects of the harvest diminished in proportion to that delay. Rain is needed in December for the germination of the barley and for sowing wheat.

January and February rains are required for the sowing of vetches, the germination of the wheat, and the development of the barley straw. A deficiency of rain in March jeopardises the barley and the wheat, and, in fact, the prospects of the harvest are governed more or less by the conditions of the weather in this month. April rains are of consequence if the ploughing and sowing have been delayed, but heavy rains in May frequently have a prejudicial effect upon the cereals, because the harvest has in many parts of the island commenced by that time.

The rainfall for June, July, August, and September is practically of no account. If any be recorded, it is partial, uncertain, and never to be relied upon; and summer crops are seldom if ever sown with any regard to rainfall, nor is any reliance placed upon anything but artificial waterings.

The rainfall recorded at six stations in Cyprus for twenty-one years is given in the Table on p. 38.

With the exception of Nicosia all these stations are on the sea-coast; and from the fact that Nicosia is at an altitude of over 500 feet above the sea, it might have been expected that this station would have recorded the greatest rainfall, but it is considerably below those of the majority of other stations. Kyrenia stands highest easily, and this may be accounted for by the fact that it is backed by a range of high mountains within a short distance of the shore, or because the surrounding country is more wooded than that of any of the other stations. The records for Nicosia in the foregoing statements have been kept at a station distinct from the Public Works Observatory.

The detailed statements covering 1899 (part) to 1902 (part) are interesting, inasmuch as they show that, during the two complete equinoctial years, *i.e.* from October 1899 to September 1901, rain was only recorded on 54 days during the first year, and on 45 days during the second year, making an average of 49·5 days for each of the two years.

Recently, under a new system, over 40 stations for recording rainfall have been established in various parts of Cyprus, by which means it will be possible to arrive at fuller particulars of the rainfall of the Island; but as the observations only cover a few months, it will be premature to discuss them in the present paper.

Wind.

During the winter the North-west wind is most frequent, but the wind blows with fair regularity from each point of the Eastern quadrant as well. During the summer, North-west is also the most frequent, and is in fact more so than during the winter, winds from the Eastern quadrant being less frequent.

RAINFALL RECORDED AT 6 STATIONS IN CYPRUS DURING THE WINTER (OCTOBER–MARCH), SUMMER (APRIL–SEPTEMBER), AND EQUINOCTIAL YEAR, 1881-1902.

YEAR.	Nicosia.			Larnaca.			Limassol.		
	Winter.	Summer.	Year.	Winter.	Summer.	Year.	Winter.	Summer.	Year.
1881–1882	7·26	3·68	10·94	4·94	1·67	6·61	...	...	...
1882–1883	12·13	2·02	14·15	10·84	0·86	11·70	...	...	...
1883–1884	19·83	1·91	21·74	14·95	1·02	15·97	19·41	1·72	21·13
1884–1885	19·72	0·56	20·28	15·35	3·05	18·40	18·60	0·63	19·23
1885–1886	12·06	2·59	14·65	11·21	0·50	11·71	20·75	0·61	21·36
1886–1887	7·83	1·24	9·07	7·60	0·99	8·59	8·51	1·41	9·92
1887–1888	6·21	7·50	13·71	7·12	3·47	10·59	17·87	3·51	21·38
1888–1889	10·73	2·79	13·52	12·27	1·80	14·07	17·06	0·30	17·36
1889–1890	15·91	3·61	19·52	16·00	1·20	17·20	16·40	1·07	17·47
1890–1891	15·60	4·09	19·69	16·12	1·95	18·07	19·28	0·85	20·13
1891–1892	6·68	3·64	10·32	8·44	0·81	9·25	9·91	1·23	11·14
1892–1893	14·59	4·47	19·06	14·80	0·58	15·38	18·13	2·34	20·47
1893–1894	16·45	2·92	19·37	16·79	2·32	19·11	20·66	4·02	24·68
1894–1895	11·04	2·23	13·27	17·01	1·87	18·88	12·47	1·81	14·28
1895–1896	12·47	0·73	13·20	17·04	0·97	18·01	22·10	0·40	22·50
1896–1897	9·56	2·01	11·57	9·23	4·63	13·86	12·03	3·70	15·73
1897–1898	11·02	0·51	11·53	15·42	0·06	15·48	15·74	0·28	16·02
1898–1899	7·91	2·67	10·58	12·43	1·92	14·35	13·12	2·06	15·18
1899–1900	11·48	2·26	13·74	13·37	1·83	15·20	17·48	0·73	18·21
1900–1901	9·42	3·70	13·12	14·59	5·37	19·96	14·82	2·90	17·72
1901–1902	5·33	1·41	6·74	5·35	0·91	6·26	9·01	1·19	10·20
Means .	11·58	2·69	14·27	12·42	1·80	14·22	15·97	1·62	17·59

YEAR.	Famagusta.			Paphos.			Kyrenia.		
	Winter.	Summer.	Year.	Winter.	Summer.	Year.	Winter.	Summer.	Year.
1881–1882	11·42	3·16	14·58	12·56	4·76	17·32	11·16	4·86	16·02
1882–1883	16·15	2·03	18·18	13·70	1·73	15·43	20·11	0·52	20·63
1883–1884	22·55	2·26	24·81	23·68	0·48	24·16	22·43	2·70	25·13
1884–1885	18·68	1·40	20·08	18·74	0·59	19·33	20·30	2·65	22·95
1885–1886	17·54	0·80	18·34	21·32	0·30	21·62	18·34	1·20	19·54
1886–1887	7·19	2·04	9·23	9·64	0·80	10·44	10·50	1·73	12·23
1887–1888	10·01	3·51	13·52	18·10	5·32	23·42	18·76	4·77	23·53
1888–1889	13·87	0·23	14·10	17·77	0·70	18·47	18·67	0·59	19·26
1889–1890	16·36	1·31	17·67	21·21	1·25	22·46	28·71	3·19	31·90
1890–1891	19·66	3·47	23·13	25·89	1·48	27·37	24·00	4·54	28·54
1891–1892	12·94	1·30	14·24	13·66	0·72	14·38	13·09	2·53	15·62
1892–1893	19·16	1·50	20·66	14·77	2·35	17·12	27·93	2·85	30·78
1893–1894	21·72	3·29	25·01	17·23	3·69	20·92	29·14	3·62	32·76
1894–1895	18·28	2·12	20·40	19·91	2·33	22·24	20·97	0·46	21·43
1895–1896	15·73	1·24	16·97	20·72	1·32	22·04	14·88	0·72	15·60
1896–1897	11·46	3·70	15·16	15·29	1·33	16·62	19·28	1·03	20·31
1897–1898	16·57	0·53	17·10	19·14	0·43	19·57	20·50	0·22	20·72
1898–1899	10·84	1·06	11·90	13·39	1·36	14·75	11·62	2·14	13·76
1899–1900	9·11	0·97	10·08	19·08	0·43	19·51	23·44	0·10	23·54
1900–1901	14·17	1·58	15·75	13·24	3·79	17·03	17·11	2·15	19·26
1901–1902	5·65	0·49	6·14	13·05	1·35	14·40	12·32	0·64	12·96
Means .	14·72	1·81	16·53	17·24	1·74	18·98	19·20	2·06	21·26

With regard to the mean of the whole year, the prevailing wind was the North-west. The next in order was the South-east; the third, North-east; the fourth, East; the fifth, West; the sixth, South-west;

the seventh, North; and the eighth, South. Calms were recorded on 88 occasions out of 725, or in the proportion of 88 : 637.

It is worthy of remark that the North and South are the least frequent quarters from which the wind blows, but this feature is no doubt explained to a certain extent by the configuration of the country in the neighbourhood of Nicosia. Nevertheless, it does not explain why the wind blows more frequently from the North—bounded as Nicosia is on that side by a range of mountains 2000 ft. high, not much over eight miles distant—than from the South, on which side the country is comparatively open.

For the winter season, and during the coldest month, namely, January, the wind blows from the Eastern quadrant, and due East is the most frequently recorded direction, North-east coming next. February is the next coldest month, and also the calmest; and it is seen that Easterly and South-easterly are the most frequent quarters.

One would have been inclined to suppose that the source of low temperatures in the plains would have been found in the high mountains of the Island, in which case South-westerly winds ought to prevail in the coldest months; but it is obvious that the actual source is from abroad, probably in the hinterland of Asia Minor, the high peaks of the eastern Taurus, or in western Kurdistan.

For the summer winds, those for the hottest month of the year, namely, July, blow with fair proportion through the Eastern and Western quadrants; and the absence of any one prevailing quarter may account to some extent for the high temperature, though this is unlikely, seeing that the highest radiation readings—solar, both *in vacuo* and exposed, as well as terrestrial—are recorded during this month.

The month of August, to which popular belief ascribes the greatest heat, is by no means, and for various reasons, the hottest month. Firstly, it enjoys a prevailing North-westerly wind for a greater number of occasions than any other month of the year, and the radiation instruments all record lower temperatures.

The records for May show prevailing winds from the Eastern quadrant, and these are for the most part due to the occurrence usually about this period of the hot, dry "Siroc," a wind which probably has its origin in the great Syrian desert, and which blows with some strength, though not violently, for some two or three days at a time. The Siroc is usually the harbinger of summer; but though it is accompanied by a higher temperature than is usual, it does not mark the termination of the cool season, and lower temperatures follow after the passage of the wind—still, it always hastens the development of the crops. Its occurrence early in the year causes a premature development of both the grain and fruit, and frequently seriously affects both crops.

Northerly gales are occasionally recorded during the colder months of the year, of a character similar to the "Tramontana," and not infrequently alluded to under that name. In this case, however, it has traversed the mountains of Anatolia, at that time covered in deep snow, hence it is remarkable for the low temperatures which accompany it. Squalls of a cyclonic character are recorded from time to time, and have their origin almost invariably in the west. Dust storms are of fairly frequent occurrence also from the same direction.

To those who have never witnessed one, the approach of such a storm has a remarkable appearance, and that alluded to hereafter among the "Phenomena" as having occurred on October 19, 1901, was especially so. At a distance of 10 miles or so it was of a dull brown hue, and stretched from the southern to the northern mountain ranges, completely across the central plain. It bore the appearance of a heavy rainstorm, obscuring both the sky and landscape, and through the haze which accompanied it the sun shone with that lurid glow which is sometimes seen on a winter's morning through the haze of London. A slightly higher temperature was distinctly noticeable; and no small wonder resulted from the discovery that the opacity was not due to rain or moisture, but to minute and penetrating dust. Light rain followed the storm, but not until after the atmosphere had cleared, a change due in all probability to the precipitation of the dust by the falling rain.

Miniature whirlwinds, or "Dust-Devils" as they are called, are a feature of the dry, hot months of the year, and are remarkably frequent at such times. To the casual observer there is something almost uncanny in the mysterious appearance—seemingly from nowhere, and originating from no visible causes—of a column of dust, whirling around and mounting upwards, in some cases for hundreds of feet, moving slowly and with deliberate paces across the landscape, like some gigantic phantom, till its crown expands mushroom-fashion, scattering its burden of fine matter far from the place of its origin, and eventually disappearing as though in distant ether. It has well earned its diabolic title.

No doubt such whirlwinds occur frequently in other countries, but that they are apparent only in those where the climate is hot and dry is due probably to the minuteness and the excessive dryness of the dust in the latter.

Velocity.

The observations recorded of the lateral movement of the air by a Robinson anemometer, so far, are for the most part so widely different in the relative months that it is hardly just to strike a mean between them.

The following are the figures, however, for the mean daily movement during two years :—

Month.	1900. Miles.	1901. Miles.	Mean. Miles.	Month.	1900. Miles.	1901. Miles.	Mean. Miles.
January	40	95	67	July	32	107	69
February	65	86	75	August	103	109	106
March	105	118	111	September	50	65	57
April	98	105	101	October	71	59	65
May	50	98	74	November	73	36	54
June	39	102	70	December	80	50	65

All that can be said or concluded from these figures with safety is that the wind blew with greater force during 1901 than during the previous year. Perhaps, also, it might be added that for the winter months March is the stormiest, and for the summer August; next comes April. For all three months the North-westerly winds are the most frequent. Is it permitted to conclude from this that the strongest winds blow also from the prevailing quarter, namely, the North-west?

The detailed records show, however, that the greatest lateral movement was 446 miles on April 9, 1901. The next was 376 miles on August 25, 1901. The highest velocity recorded on individual days was as follows :—

Velocity. Miles per Hour.	Period.	Date.	Direction.
21·7	From 9 a.m. to 3 p.m.	April 19, 1901.	E. and S.
16·55	,, ,,	May 22, 1901.	S. and S.E.
16·3	,, ,,	April 26, 1901.	E.S.E. and E.N.E.

These were probably all due to Sirocs, and it is more than likely that these velocities are exceeded for short periods which could not be recorded except with the aid of automatic apparatus.

Phenomena.

Among the phenomena recorded are the following:—

1900.

January 5.—Smart earthquake shock at 2.50 a.m.; duration about 15 seconds. Many buildings in various parts of Cyprus sustained slight injuries.

January 17.—Snow fell for upwards of an hour in Nicosia.

May 18.—A heavy flood occurred during the afternoon; the Pedias river rose abnormally high. The rainfall recorded in Nicosia was, however, slight.

1901.

May 22.—A cyclone of brief duration occurred during the afternoon from the West and West-north-west. For a space of about half an hour the wind blew with hurricane force, dismantling the campanile of the church of Engomi, near Nicosia, causing damage to the Nicosia Hospital and other buildings. It was accompanied by incessant thunder, vivid lightning, and hail of which some of the largest stones measured three-quarters of an inch in diameter; 0·88 in. of rain was recorded as having fallen in the space of one hour, and severe damage was caused to the crops then being harvested, a considerable quantity being dispersed by the wind. The solar radiation thermometer at the station was broken by the hailstones.

October 9.—A heavy dust-storm occurred at 3.40 p.m., accompanied by high winds, and followed by light rain.

1902.

January 17.—Three slight shocks of earthquake were observed at 12.9 p.m.

February 20.—A dust-storm with high wind at 11.30 a.m., followed by light rain.

March 14 and 15.—Heavy snow fell on the neighbouring mountains down to the 1000 ft. level.

March 26.—A dust-storm with high winds, followed by heavy rain.

As in all dry, hot climates and flat countries, so in Cyprus, remarkable instances of the mirage are frequently witnessed. In the calm of a summer morning may be seen extensive lakes where none actually exist, and in the distance the villages studding the plain become transformed into veritable cities of palaces; low, one-storied huts range themselves into façades of sky-scrapers apparently rising some two or three hundred feet in height, gigantic palm-trees overshadowing all.

Visibility, the intense clearness of distant objects, is a feature of the cooler seasons of the year. The distant landscape and every rock on the mountain side appear in the minutest detail, even the colour of the trees is distinctly discernible at distances of 15 and 20 miles. The profile of the grey hills is shown clearly-defined and sharp-cut against a back-

ground of incomparably blue sky, while the nearer landscape ranges through all the shades of chrome and ochre; every shade of colour in earth and sky, every detail of the scenery intensified by the rare purity of the atmosphere. At such times it is easy to realise how, coupled with the history of her glorious past, Cyprus fulfils all the conditions of

> A land of clear colours and stories,
> A region of shadowless light;

and, indeed, as one stands amid the ruins of her ancient palaces, visions, unbidden, spontaneous, arise of such scenes as that portrayed in the beautiful painting to which the artist has appended the couplet just quoted.

At such seasons, also, as the sun approaches the horizon, the landscape is diffused with a pale lilac tint, deepening as he sets and disappearing as he sinks below the horizon, giving place to marvels of colour in the afterglow of a cloudless sky, and in crepuscular rays or sun-pillars, reflected in the eastern sky as evening gives place to night.

A remarkable instance of audibility, deserving to be recorded, was recently communicated to the author. In happier times Cyprus boasted a garrison of a battalion of infantry who, during the summer months, were encamped at Troödos. It was asserted, with a degree of assurance which removed all doubt, that the strains of the military band when playing at Troödos, could be heard distinctly in, and in the neighbourhood of, the village of Agros, which is fully 8 miles distant as the crow flies. Now the camp at Troödos is at an altitude of about 5500 ft. Agros lies in a hollow surrounded by hills rising to something over 5000 ft., and is to the eastward and leeward of Troödos. Beyond Agros, still farther east, the conspicuous mountain of "Papoutsa" rises abruptly to 5124 ft.; and on the western side of the village and close above it the hill known as "Phterikhi" rises to 4156 ft. Agros is probably about 3500 ft. From Papoutsa the main ridge connecting it with Adelphi, 5305 ft., forms an irregular horse-shoe around the northern side of the village. No doubt the configuration of the country lends itself to the phenomenon; and it may be fair to assume that the waves of sound are borne by the wind over the village, striking the shoulder of Papoutsa, are thrown back upon Phterikhi, and are thence deflected to the village. While there is no way of proving the statement, there is little reason to doubt its veracity.

In matters connected with phenology, the migration of birds, and phenomena indicating a change of season, the most conspicuous is that relating to the movement of the cranes. These birds, save in a few instances only, spend neither the summer nor the winter in Cyprus, but migrate between Africa and their breeding-grounds in Asia Minor or elsewhere to the north of Cyprus. They are, so far as Cyprus is concerned, for the most part, merely birds of passage. They go north usually in the latter end of February or the beginning of March, and south in the latter end of August or the beginning of September, and, with the infallibility of instinct, herald a change of season. Their arrival in the autumn is concurrent with that of the ortolans or "Becca-ficoes," and popular belief ascribes the coincidence to the fact that the latter are borne across the intervening seas on the backs of the cranes.

The steady course of the cranes and the almost military precision of their movements and dispositions on the line of flight are not the least remarkable features of these strange birds. It is the general belief that an early appearance in the autumn indicates an early or a severe winter; but as in 1901 they appeared on August 28, rather earlier than usual, and as the following winter was by no means severe, but was, on the other hand, the driest recorded for 20 years, there are strong grounds for doubting this forecast.

Conclusion.

In the foregoing remarks nothing more than a sketch of the climatic conditions prevailing in Cyprus has been attempted. To have gone more deeply into the subject would have incurred considerable labour, which would have been stultified by the fact that for a certain part of the period covered by the records dealt with in this paper, the observations are not wholly above suspicion on account of the quality of the instruments comprised in the observatory in the days of its commencement. Everything must, however, have a beginning, and so therefore if the records herein dealt with are accepted in the spirit in which they are offered, the information which they convey will at least be interesting, if not of very high value from a scientific standpoint.

Among the principal characteristics of the climate of Cyprus is that of the temperature. Cold winters following upon hot summers, heat frequently in excess of that of many tropical countries, make the former felt the more acutely by the contrast they afford. A range of temperature through 80° speaks for itself. This fact offers one of the most serious questions calling for solution in the economies of daily life, namely, the style of house which should be adopted, possessing the virtue of being warm in winter and cool in summer. The native has, from long consideration of the most economic and withal efficacious means of bringing this about, built his house in the past of mother earth in the form of sun-dried bricks, with a roof of mud, or "adobe," than which no better non-conductor of heat can be found, and without doubt this is the proper style to adopt. But civilisation has introduced western ideas, and the better-class houses are now built of stone and are covered with pan-tiles; the result, while it certainly possesses the perhaps doubtful virtue of smartness on the outside, is that the interior is frequently excessively hot in the summer months, and too cold to be pleasant during the winter.

In the Middle Ages, when labour and materials were both cheaper than to-day, men built their houses of masonry some feet in thickness, with a vaulted roof in keeping, but among the questionable blessings of civilisation and advancement are the increased prices for both labour and materials, and no man can now afford to build his house on these lines. Thus, therefore, comfort is sacrificed to appearance, and men have not yet realised that they do not live on the outside of their houses.

Yet for all the heat of the plains, Cyprus possesses in Troödos a health resort which could hardly be surpassed in any country in the world. For 4 months at least this sanitarium boasts an almost ideal climate, within easy reach of Egypt and the other countries of the Levant, and connected now by a good carriage road with the seaport of Limassol. Few who have not experienced the charms of the place can

realise the attractions that it offers, or can appreciate the welcome change it affords from the scorching heat of the low country of this part of the world. The dry, bracing air, the hygienic aroma of the pine-trees, all conduce to that renewal of wasted energies which are so marked a result of long residence in hot climates—with every breath comes re-invigoration.

The attractions of Cyprus, moreover, as a winter resort are not few, and while those resident in the Island are in the habit of considering the winter cold, this belief is merely the result of exposure to the heat of the summer which has preceded it. Through the months of December, January, February, and March, the climate of Nicosia is pleasant and bracing. Heavy rains of long duration are unknown, and very shortly after the fall of rain the weather clears, and the warm sun soon dries up any excessive moisture.

At all times the atmosphere is freely charged with electricity, whose presence is observed through the simple operation of brushing the human hair, during which the hair is frequently observed to stand out straight from the head, and, as the brush passes over it, to give forth a crackling sound like the discharge of so many diminutive rifles fired in rapid succession. Yet withal thunderstorms are not frequent, nor are they remarkable for their violence, while damage by lightning is the exception rather than the rule. There are no apparatus at the station for measuring the amount of electricity present in the atmosphere.

DISCUSSION.

Mr. J. A. Curtis thought the author should be congratulated on an interesting and informing paper, but it seemed a pity that he had not availed himself of the very full observations taken at the six Government stations. These observations were copious and valuable, and gave a comprehensive view of the climatic conditions of Cyprus since 1881. Mr. Bellamy gave no account of the exposure of his instruments, although he had evidently taken much pains to secure good ones. This appeared a grave defect. Much criticism of the paper was, however, debarred through the frankness of the author's statement as to the conditions under which it was written. The observations themselves appeared to agree well with those of the Government station. The author spoke of January as being considerably the coldest month of the year in Nicosia, and July as the warmest. He, Mr. Curtis, had, however, observed very little difference, as a rule, between the temperatures of January and February on the one hand, and July and August on the other, the means for 10 years, 1881-90, being January 49°·5, February 50°·5; July 83°·8 and August 83°·3. One other point which struck Mr. Curtis was that the highest mean maximum temperature of Nicosia was stated as reaching 106°·5. He imagined this must be intended for the mean of the extreme highest for 2 years. If, as stated, the highest maximum was 108°, it seemed almost incredible that the mean maximum could be 106°·5. The lowest temperature, according to the Government observations, was 13°·0 on March 28, 1898, as against 28°·0, the lowest observed by Mr. Bellamy. The observations of the depression of the wet-bulb thermometer appeared to agree very fairly with the official statistics. The rainfall observations, too, seemed very correct, and the monthly results for the six stations for the whole period of 20 years were given in the paper, which was a great advantage. With regard to wind-direction, the Government

records showed a great preponderance of Easterly and Westerly winds, while Mr. Bellamy's pointed to a prevalence of North-west and South-east. The wind-velocity was probably tested by a small-pattern cup-anemometer, but nothing was said as to its exposure, nor whether the instrument was constantly recording or merely one of a hand pattern. Had more information on this point been given we should be in a better position to judge upon it. The last paragraph, relating to electricity, he (Mr. Curtis) had heard with surprise. He had not known of any stiffening or crackling of the hair from any persons who had been in Cyprus.

Mr. F. C. Bayard remarked upon the value of the information which Mr. Curtis's comments on the paper conveyed. They enabled every one to see what the paper really contained and to form a judgment upon those observations which Mr. Bellamy had given.

Mr. E. Mawley thought that the author was to be congratulated upon having written a very interesting paper. He agreed with Mr. Curtis in thinking it unfortunate that more information was not given concerning the instruments and their methods of exposure. It was, however, satisfactory to learn that, upon the whole, the two sets of observations agreed fairly well. There could be very little doubt but that the mud-houses described in the paper were superior in such a climate to those built of stone, both as regards warmth in winter and coolness in summer. For horticultural purposes Mr. Mawley considered that loose earth was only second to snow in affording protection in winter to low-growing plants. For instance, delicate tea-roses, which early in December had been earthed up like potatoes, would withstand the most severe frosts. Under such circumstances those parts of the plants which were above the soil had frequently been found completely destroyed, while an inch beneath the covering the same shoots were altogether uninjured. Owing to the dryness of the summer the seasons in Cyprus as affecting vegetation appeared reversed to those in England, as growth was only possible in Cyprus during the cooler and moister months of the year. The author's method of dividing the year into two distinct halves he considered an excellent one, and more particularly as regards rainfall. In England, for instance, except from a strictly meteorological point of view, it was very misleading to begin calculating the rainfall from January 1. In his opinion the winter half of the year should be kept entirely distinct from the summer half. For it was virtually only the winter rainfall which went to nourish the springs, and only the summer rains which benefited vegetation.

Dr. R. H. Scott thought the information given in the paper interesting, and said that he himself was in possession of a curious piece of information, viz. that in ancient times Cyprus was believed to be the only land in which a ship could be built, rigged, manned, and equipped for sea without any outside aid whatsoever.

Mr. B. Latham said, with reference to the observation in the paper that a low reading of the barometer was almost invariably accompanied by an increased activity in the Soufrières, and that a greater volume of sulphurous gases was given off, he might mention that it entirely corresponded with observations in this country, as it was well known that springs increased in flow with the fall of the barometer, which was due to the alteration of the tension of the enclosed gases or air. Moreover, the "blowing wells" at Northallerton in Yorkshire clearly indicate that there is a great current of air out of these wells when the barometer is falling, and an in-current when the barometer is rising. This is no doubt due to the tendency to produce an equilibrium between the pressures of air and gases in the ground and the air outside. There was every reason to feel sure that Mr. Bellamy was not the man to have his instruments placed in any but the best position for recording, and he might be trusted as

to the proper arrangement of his apparatus, and regarded as perfectly competent to deal with his subject. All were indebted to him for his interesting and valuable paper.

Mr. Edward Atkin said he had resided 4½ years in Cyprus, chiefly at Nicosia, and he agreed with Mr. Bellamy about the prevalence of wind blowing from West-north-west. He had, in fact, good reason to remember this, as he had once been prevented, when yachting, from landing on the island on account of this wind. He found that Dr. Scott's statement about ships and ship-building held good at this day. Coasting craft were built at Limassol. He had lived in both kinds of houses named by the author, viz. those built of stone with tiled roof, and those of sun-dried bricks of mud and straw with mud roof. He had found the latter cooler in summer and warmer in winter; they better withstood seismic disturbances than stone-built dwellings. He did not entirely agree with Mr. Bellamy about the migration of birds. Many bred in the island, and he had found the ortolan in the Nicosia district and the crane in the marshes around Famagusta. He had never experienced, nor heard of, the remarkable electric conditions when brushing the hair, mentioned by the author. While living in the island he had thought it interesting to note the supply of the rivers from the mountains, and this not only in the spring. Upon one occasion he with a friend had crossed the dry bed of the river Pedias at 4·30, and on returning at 5·30 found 6 feet of water in place of the dry land, caused by the rapid melting of the snow on Troödos and the rushing down of the water from the mountains. Mr. Bellamy had perhaps not dwelt enough in his paper upon the advantage to cultivation of these melting snows and also of the heavy dewfall in summer. The audibility in the island was particularly noticeable, and he (Mr. Atkin) had heard quite distinctly a band playing in one of the villages on the southern slope of Troödos when he was standing at the top of one of the mountains at least 8 miles from the band; and the tinkling of sheep and goat bells was almost always to be clearly heard long before the flock came into sight. The author's description of the gorgeous sunsets was perfectly true to nature. He (Mr. Atkin) would offer one remark upon the reasons given for differences in the rainfall of the island. In the district of Kyrenia, which was well covered with trees, the inhabitants were careful not to cut down without replanting, whilst in the south-western district they were careless about this, and the Government had done all in its power to prevent reckless destruction of timber and to protect young trees. The clearness and non-corrosive quality of the air was most remarkable, and he (Mr. Atkin) had seen in the chapel of a castle of the fifteenth century, of which the roof had long fallen in, paintings and figures upon the walls in excellent preservation; whilst on most of the tombs of the Crusaders the inscriptions were still perfectly distinct and legible.

THE ECLIPSE CYCLONE OF 1900.

By H. HELM CLAYTON.

[Read December 17, 1902.]

SINCE the publication in the *Quarterly Journal* (Vol. XXVII. p. 269)[1] of my paper on "The Eclipse Cyclone, the Diurnal Cyclones, and the Cyclones and Anti-cyclones of Temperate Latitudes," the observations made by the United States Weather Bureau have appeared in print (*U.S. Department of Agriculture, Weather Bureau, Bulletin I.:* "Eclipse Meteorology and Allied Problems").

These observations appear to me to confirm the conclusions at which I had arrived concerning the meteorological effects of eclipses, and deserve further comment.

In Fig. 1 are given the curves drawn by Prof. Bigelow to represent the means of the Weather Bureau observations, averaged in groups at different distances from the central line of the eclipse. On the left-hand side of the diagram are given successively the numbers assigned to the different groups, the number of observing stations in each group, and the mean distances from the central line of the eclipse. The mean of the observations along the area where the eclipse was total is given near the middle of the diagram, and the results at successive distances north and south are plotted on each side of it. The vertical lines in the diagram represent intervals of 15 minutes. The central line marked *Total* gives the time of maximum eclipse, and the dotted lines give respectively the mean times of the beginning and of the end of the eclipse. These dotted lines and the letters *a*, *b*, *c* do not appear in the original diagram.

Before commenting on Fig. 1, it will be well to recall the theory of the eclipse cyclone, to which I was led by the observations in this and in preceding eclipses. This theory is illustrated by Fig. 2. In this diagram the continuous line represents a ring of high pressure at the outer edge of the eclipse shadow; the broken circle represents an inner ring of low pressure; and the letter B indicates the position of a central area of high pressure. If such a condition should progress from left to right, following the shadow of an eclipse, it will be seen that stations along the central line A, B, C would experience maxima of pressure at A, B, and C, and minima of pressure between A and B and between B and C coinciding with the position indicated by the broken line. The vertical lines represent distances travelled in 15 minutes by the eclipse shadow. The central line is marked zero, and the others for 15-minute intervals preceding and following this epoch. Examining further the conditions which would follow from theory as the eclipse moved across a given area, it is evident that stations along the line A′, B′, C′ would experience maxima of pressure at A′ and C′ and a minimum at B′. In other words, the outer maxima have come inward toward the central line and the central maximum has disappeared. Now suppose that an average of the conditions at a number of stations lying between the lines A′, B′, C′ and A, B, C be taken. It is evident that the results at the different stations tend to neutralise each other. The maxima at

[1] See also *Annals of Harvard College Observatory*, vol. xlii., part 1.

stations near A′ and C′ tend to occur at the same time as the minima at stations between A and B and between B and C respectively. The

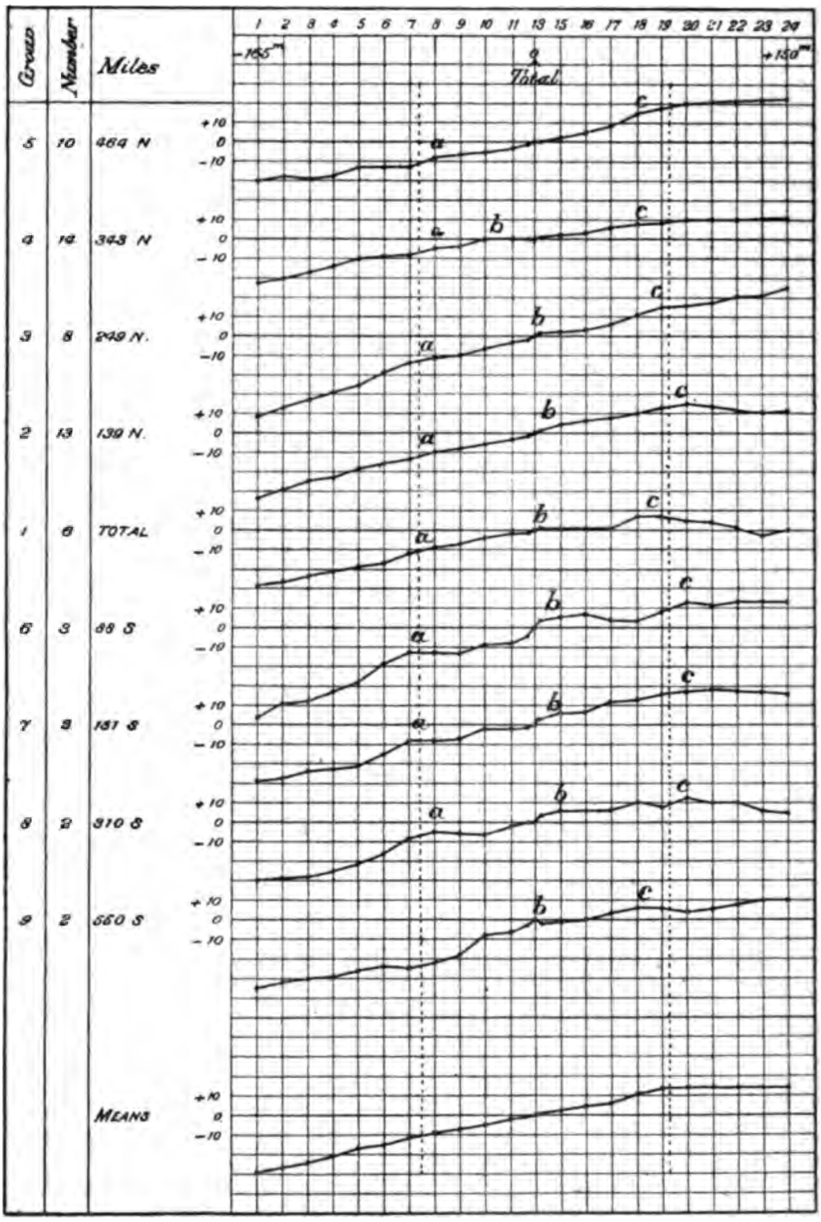


FIG. 1.—Barometric Pressure Variations.

minimum at stations near B′ coincides in time with the maximum at stations near B. Hence in a general average these would tend to neutralise each other and eliminate the eclipse effect.

All of these phenomena are indicated more or less distinctly by Prof. Bigelow's curves (Fig. 1). Independent of the eclipse all the curves show a general rise due to the diurnal rise of pressure at the time of the eclipse, combined with the movement of an ordinary anti-cyclone across the Southern States of the United States. But, in addition to this general rise, there are indications in most of the curves of three maxima and two minima during the passage of the eclipse shadow. These maxima are marked by the letters *a*, *b*, *c*. Examining the maxima *a* and *c*, it is seen that midway between the top and bottom of the diagram, or, in other words, near the middle of the track of the eclipse, these maxima tend

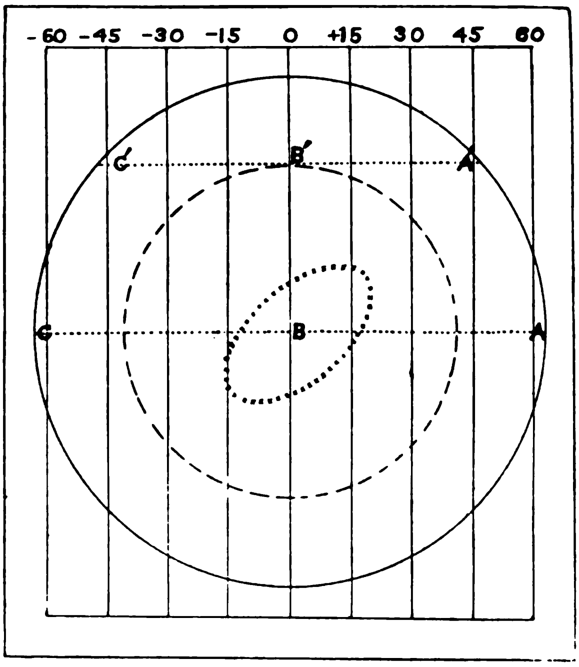


Fig. 2.

to occur farthest from the central vertical line, as theory would indicate. Furthermore, in accordance with the theory, the maximum *b* is largest in the central groups, and diminishes so as to be scarcely distinguishable in the extreme northern groups. In the extreme southern group the flattening is less marked, either because of the smaller number of stations failing to give a smooth curve, or because the central maximum extended farther from the centre on that side. None of these groups are as far from the centre as the line A′, B′, C′ in Fig. 2. The maximum *b* appears to be largest in the group immediately south of the line of totality, and it is noteworthy that this is also the group showing the largest fall of temperature. When the positions of maximum *b* in the various groups are charted on Fig. 2, the separate maxima are seen to lie roughly along the axis of an ellipse, such as is represented by the line of small crosses. South of the line of totality the maximum *b* appears to have occurred a

few minutes later than the time of maximum eclipse, while north of this line it appears to have slightly preceded the maximum of eclipse.

In order to compare the results of the Weather Bureau along the belt of total eclipse with those in this belt in previous eclipses, I have treated these observations in the same manner as was done with the observations in previous eclipses. The rise of pressure during the eclipse, due to the diurnal rise at that time of day and to the movement of the anti-cyclone, was separated from the changes taking place during the eclipse by computing a uniform rise from the beginning to the end of the eclipse and subtracting this from the observed values. This method does not entirely eliminate the diurnal period, but renders the residual errors small in comparison with the changes taking place during the brief interval of the eclipse.

The mean pressure departures derived by the Weather Bureau from the six stations in the belt of totality at intervals of 15 minutes for 90 minutes preceding and following totality are given in the line indicated by the word "means" in the following table. The figures between the thick rules show the observed values while the stations were within the eclipse shadow.

CHANGES OF PRESSURE DURING ECLIPSES.

(In thousandths of an inch of mercury.)

Eclipse.		Began.					Total.					Ended.	
Time in minutes .	−90	−75	−60	−45	−30	−15	0	+15	+30	+45	+60	+75	+90
Means . .	−16	−12	− 9	− 7	− 3	− 2	·000	+ 1	+ 1	+ 2	+ 7	+ 7	+ 4
Uniform Rise .	−13	−11	− 9	− 7	− 5	− 4	−·002	0	+ 2	+ 3	+ 5	+ 7	+ 9
Eclipse Pressure 1901	− 3	− 1	0	0	+ 2	+ 2	+·002	+ 1	− 1	− 1	+ 2	0	− 5
Eclipse Pressure 1887-1900	0	+ 1	0	− 2	− 3	0	−·001	− 4	− 5	− 3	− 1	. 0	− 2

The values in the line below the line of means are derived from a computed uniform rise of pressure during the eclipse. The difference between these and the means of the observations give the changes of pressure attributed to the eclipse. The values in the lower line of the table give the mean changes derived from observations in the belt of totality during four eclipses from 1887 to 1900. The observations during the first three eclipses were taken by Prof. Upton and Mr. Rotch, and during the eclipse of 1900 by Mr. Fergusson. These observations were taken with great care. The barometers were sensitive aneroids carefully compared with standards, and in one of the cases as many as four separate barometers were read. In all the cases every effort was made to eliminate errors. For this reason it is believed that the mean values represent very approximately the true changes of pressure due to an eclipse. The values in the last two lines of this table are plotted in Fig. 3.

It is seen that the first maximum in the curve derived from the observations of the Weather Bureau is somewhat obscure, but the general

contour of the curve is the same as that derived from previous eclipses, and there are points of marked agreement. The number and positions of the maxima and minima are almost identical. The chief minimum occurs between 30 and 45 minutes after the total eclipse. The mean range of pressure between the central maximum and the succeeding minimum, according to the Weather Bureau observations, is ·003 in., and according to the mean of previous eclipses it is ·005 in. The position and amount of rise of the third maximum near the end of the eclipse is also nearly the same in the two cases. In fact, considering

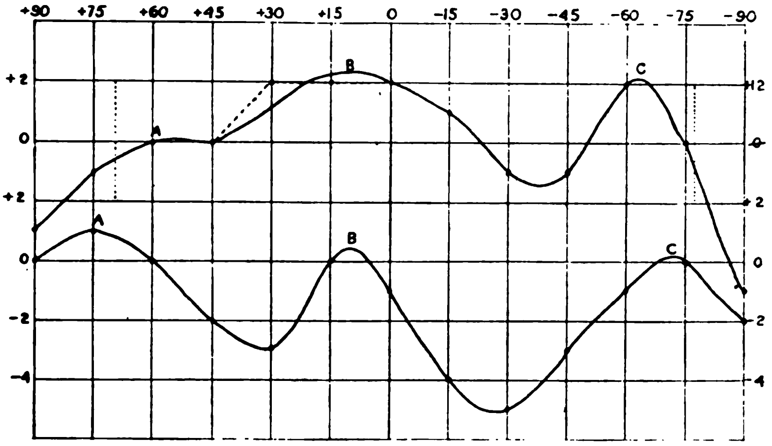


Fig. 3.

that the observations were made in different countries, in different seasons, and at different times of the day, it seems to me there is a remarkable agreement. In opposition to my view, however, it is well to state that Prof. Bigelow does not feel sure of the reality of the changes derived from the Weather Bureau observations. In *Science* (N.S., vol. xiii. p. 591) he says: "The Weather Bureau observations at sixty-five stations confirm the Clayton distribution of pressure . . ."; but in the later *Bulletin* of the Weather Bureau he takes the more cautious position that: "An inspection of these curves for evidences of characteristic changes of pressure due to the effect of the moon's shadow shows that there may be a slight rise at Nos. 15, 16, that is 15 to 30 minutes past totality, with drops at Nos. 10, 11, and 17, 18; but this is very uncertain, and the mean curve is so smooth that this cannot be positively asserted."[1] The numbers in this quotation refer to the numbers at the top of Fig. 1, and coincide with the maximum marked *b* and with the minima between *a* and *b* and between *b* and *c* respectively. According to this last quotation, Prof. Bigelow's thought seems to have been largely influenced by the smoothness of the mean curve; but, as previously shown, this smoothness is exactly what is demanded by theory. The Weather Bureau stations extend over a belt about 1000 miles wide; and, as has been pointed out, the maxima *a*, *b*, and *c* are not simultaneous in time

[1] P. 27.

in the different groups of stations. Hence they tend to efface each other in the mean.

In regard to the winds, Prof. Bigelow says: "The variations in the azimuth were on the average very small during the eclipse, and the means seem to indicate that there was no definite change in the azimuth or direction of the wind which could be attributed to the eclipse."[1] In this opinion I think he is again misled by relying on the general average or mean; and the individual observations of the Weather Bureau, which were only made to eight points of the compass, are probably not minute enough to show the small changes due to the eclipse.

In regard to the wind velocity he says: "Since the velocity is a little greater before the shadow reached a given point, and less after it has passed, and considering that the prevailing South-west wind—that is, a vector motion toward the north-east—is feebly accelerated in front but retarded in the rear of the shadow, it is evident that this is equivalent merely to an outflow on all sides from the entire region covered by the shadow."[2]

This confirms the prevailing outflow which I have found within the shadow, and it is difficult to conceive how such an outflow could take place without being more or less deflected into an anti-cyclonic circulation by the earth's rotation.

Prof. Bigelow found a fall of temperature near the central area of the eclipse of between 3° and 4°; but this amount is probably not so trustworthy as the larger amounts found by Mr. Rotch with an aspiration thermometer, and by Mr. Pickard and myself with sling thermometers whirled in the shade in the open air, because the observations used by Prof. Bigelow were obtained in the ordinary shelter, which is subject to sluggishness in a light wind and in a brief change of temperature like that of the day of the eclipse. No increase in the number of observations can eliminate a constant error like that of sluggishness.

In his final remarks Prof. Bigelow urges certain reasons against accepting an explanation of the eclipse phenomena as due to a cold-air cyclone. The most important of these is the objection that the coefficient of friction is too small for the dynamic circulation to produce a central anti-cyclone. Now, neither Prof. Ferrel nor myself claim that the central anti-cyclone within or beneath a cold-air cyclone is due to a dynamic circulation, but that it is due to an increased density of the air from cold. This and his further remarks lead to the belief that Prof. Bigelow has a misconception of Ferrel's theory. But I will not pursue the subject here, as the matter has already been discussed in *Science* (vol. xiii. p. 747).

The deductive and mathematical side of this subject will no doubt in time be fully worked out. Prof. Luigi de Marchi has already contributed such a paper to the Lombardy *Rendiconti* (see *Nature*, vol. lxvi. p. 159), and others will undoubtedly follow.

DISCUSSION.

The President (Mr. W. H. Dines) said he thought they were much indebted to Mr. Clayton for his trouble in working up the large numbers of figures on which his diagrams were based. The subject was, in his opinion, one of great interest,

[1] P. 41. [2] P. 43.

and from the theoretical side one of extreme importance. The eclipse provided an external source of cooling to the air, passing over the lighted portion of the hemisphere at a definite rate, and afforded the only means perhaps available of determining the changes of pressure that may be produced by a change of temperature over a rapidly shifting area. Probably the cooling produced by the shadow only extended to a few hundred feet elevation; taking it as 500 feet, and supposing that the air temperature to this height fell 5°, the corresponding rise of the barometer should be ·005 in. The air being cooled would occupy less space, and the rise of the barometer could only be produced by there being time for the surrounding air to flow in above and fill this space. It would appear from the diagrams that, notwithstanding the speed with which the shadow moved, there was ample time to set up the motion and characteristics of a cyclone; but it must be borne in mind that these results rested on the reading of a barometer or aneroid to the thousandth part of an inch. It was not likely that two separate observers would agree to the thousandth part of an inch in reading the same barometer, but here presumably the same observer would read the barometer throughout, and the accuracy of the result did not rest on the barometer itself or the reading being accurate, but only on the changes being correctly noted. Also, although the individual observations might be more or less in error, it did not follow that the average result would be so. In fact, an average, apart from any systematic source of error, soon became independent of the accidental errors of the figures that formed it. For these reasons he thought the author had established his case.

Lightning Recorder.—In the Annual Report for 1901-2 of St. Ignatius College, Cleveland, Ohio, the Rev. F. L. Odenbach publishes an appendix on the work of his meteorological observatory during the past year. This begins with an account of his new lightning recorder, or ceraunograph. He says that on seeing the first working model of the apparatus for wireless telegraphy and its action under the influence of electro-magnetic waves, he came to the conclusion that it was possible to harness lightning and force it to record its own doings. The various parts of the instrument were a relay, a telegraph sounder, a coherer, choking-coil, two batteries, a recording-drum or chronograph, a copper collector on the roof of the college, and a copper wire leading from it down to the instrument in the observatory. A lightning-flash sends out in all directions rays of electro-magnetic waves, which travel like light. The waves from a distant flash strike the copper collector and descend on the wire to the primary circuit of the relay. Their way is blocked by the choking-coil, and therefore they pass in great part through the coherer. The moment they do so this tube becomes a conductor for the primary current; the relay goes into action and closes a secondary circuit; the recording-magnet moves the pen and makes the record; but at the same time the sounder in this same secondary circuit clicks, shakes the coherer, and all is over until a second distant flash sends another electric wave. This first crude instrument worked successfully during the whole of the summer of 1901, but is now replaced by an improved apparatus in which a graphite coherer is used.—*U.S. Monthly Weather Review.*

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 19, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

WILLIAM HENRY ARCHER, Cromer;
EDWARD JOHN BENTLEY, 2 Thyra Villas, Ramsgate;
JOHN HOWARD WORTHINGTON BIGGS, Storr's Park, Windermere;
ALFRED CHANDLER, Avonlea, Paignton;
SAMUEL FRANKLIN CODY, Birdville, Texas, U.S.A.;
Prof. APURBA C. DATTA, B.A., Jubbulpore, C.P., India;
WILLIAM DIGBY, C.I.E., 7 Leinster Mansions, Hampstead, N.W.;
H. STANLEY HAWORTH, Stanley Grange, Wakefield;
JAMES PULTENEY TOLLAND, Moorside, Eccleshill, Bradford;
WILLIAM STANSFIELD TORBITT, B.A., F.R.G.S., Hull;
VIPAN MAITLAND WATERMEYER, Middleburg, Transvaal; and
HARRY BURSELL WITTY, F.R.H.S., Pearson Park, Hull,
were balloted for and duly elected Fellows of the Society.

The PRESIDENT stated that the kite experiments for ascertaining the meteorological conditions of the upper atmosphere had been carried out during the summer months off the west coast of Scotland, and that the expenses in connection therewith had been defrayed by grants from the Royal Society, the British Association, and the Royal Meteorological Society, and also by a contribution from an anonymous donor. He also announced some contributions to the Research Fund.

The following communications were read:—

1. "ENGLISH CLIMATOLOGY, 1881-1900." By F. CAMPBELL BAYARD, F.R.Met.Soc. (p. 1).

2. "THE RAINFALL OF DOMINICA." By C. V. BELLAMY, M.Inst.C.E., F.R.Met.Soc. (p. 23).

December 17, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

ASHTON CHARLES ALLEN, 21 Leadenhall Street, E.C.;
Miss EMILY ASTON, B.Sc., Renby Grange, Boarshead, Tunbridge Wells;
ALEXANDER BUCHAN, LL.D., F.R.S., 42 Heriot Row, Edinburgh;
Prof. GEORGE HOWARD DARWIN, F.R.S., Newnham Grange, Cambridge;
ARTHUR EDGELL EASTWOOD, Leigh Court, Taunton;
GRAHAM THOMAS WALTERS OLVER, Bombay, India;
FRANCIS EDWARD PHILLIPS, Woodstock, Cape Town;
THOMAS ALFRED ROUTH, 11 Beaumont Street, Marylebone, W.; and
Sir WILLIAM WILLCOCKS, K.C.M.G., M.Inst.C.E., Cairo, Egypt,
were balloted for and duly elected Fellows of the Society.

Dr. C. ALFRED ANGOT, Bureau Central Météorologique de France, Paris; and
Prof. WILLIS L. MOORE, Weather Bureau, Washington, U.S.A.,
were balloted for and duly elected Honorary Members of the Society.

Mr. F. DRUCE and Mr. T. P. NEWMAN were appointed Auditors of the Society's Accounts.

The following communications were read :—

1. "NOTES ON THE CLIMATE OF CYPRUS." By C. V. BELLAMY, M.Inst.C.E., F.R.Met.Soc. (p. 29).

2. "THE ECLIPSE CYCLONE OF 1900." By H. HELM CLAYTON (p. 47).

CORRESPONDENCE AND NOTES.

Government Grant to the Meteorological Council.—The First Lord of the Treasury has appointed a Committee to inquire and report as to the administration by the Meteorological Council of the existing Parliamentary Grant, and as to whether any changes in its apportionment are desirable in the interests of Meteorological Science, and to make any further recommendations which may occur to them, with a view to increasing the utility of that Grant.

The Committee consists of:—The Right Hon. Sir Herbert E. Maxwell, Bart., M.P. (Chairman); Mr. J. Dewar, M.P.; Sir W. de W. Abney, K.C.B., F.R.S.; Sir F. Hopwood, K.C.B., Board of Trade; Sir T. H. Elliott, K.C.B., Board of Agriculture; Dr. R. T. Glazebrook, F.R.S.; Mr. T. L. Heath, Treasury; and Dr. J. Larmor, F.R.S. Mr. G. L. Barstow, of the Treasury, will act as Secretary to the Committee.

Government Meteorological Reporter for India.—Mr. G. T. Walker, M.A., of Trinity College, Cambridge, has been appointed Meteorological Reporter to the Government of India, in succession to Sir John Eliot, K.C.I.E., F.R.S., who has resigned the office.

Swedish Meteorological Institute.—Dr. H. E. Hamberg has been appointed Director of the Central Meteorological Institute of Sweden, at Stockholm, in succession to the late Dr. Robert Rubenson, who died a few months ago. Dr. Hamberg has been connected with the Meteorological Institute since 1878.

Cracow Observatory.—Monsieur Maurice P. Rudzki has been appointed Director of the Cracow Observatory.

St. Elmo's Fire.—The following letter from Mr. J. Fellows of the White Star S.S. *Germanic*, has been forwarded by Commander M. W. C. Hepworth, R.N.R., C.B., the Marine Superintendent of the Meteorological Office :—

"On a voyage to New York in the above vessel an unusual and brilliant electrical disturbance was witnessed, which may be of interest to your Office. On September 2, 1902, and for two days previous, the wind was about Southwest true; atmosphere very humid and oppressive, and becoming more so towards evening of the 2nd, accompanied by lightning which increased in brilliancy and rapidity towards midnight. About 1 a.m. of the 3rd the whole heavens were one continuous blaze of most intense sheet lightning of a pale yellow and green colour, heaviest in the north-west. There were five or six peals of thunder, and a perfect deluge of rain lasting about fifteen minutes.

"During this time the vessel presented a remarkable appearance. On the truck of the foremast, instead of the usual electric spark there was a flame about a foot and a half high and a foot across, and from the truck to about 30 feet down the mast, balls of fire ranging from ½ inch to 2½ inches in diameter were quickly running up and down the mast in a most agitated manner. On the other masts there was only the usual spark. During this

time the wind gradually changed West, blowing moderately, except once for the space of about twenty seconds, when it reached quite force 10. The sea at any time was not more than moderately confused. The wind continued changing towards North, finally dropping calm, and in a few hours the weather was beautifully fine. The ship's position at the time the disturbance was at its height was lat. 42° 21′ N.; long. 62° 16′ W.; barometer, 30·05 ins.; air temperature, 65°; sea water at surface, 61°."

The following letter from Mr. Charles Dibdin, Secretary of the Royal National Lifeboat Institution, appeared in *Nature*, December 25, 1902:—

"It may be interesting . . . to know that we find in a report received from our local committee at Margate relative to the launch of one of our lifeboats there, viz. *Eliza Harriet*, on December 3 and 4, that it is stated that about 2 a.m. a bright light was observed on the top of each of the lifeboat's masts, also one on the lee foreyard, which remained quite three-quarters of an hour and lit up all the wire pennants, making them perfectly clear. The lights in question appeared to be of the size of a small lantern. At the time it was blowing very hard and a heavy sea was running, and during the whole time it snowed so hard that it was impossible to see a yard in front of the boat. These lights continued until nearly 4 a.m., and finally disappeared on the snow lifting. It could not possibly have been a reflection from any light on the lifeboat, as they had none showing. It seems to us that this was probably a case of St. Elmo's Fire, occasionally seen in a highly electrified state of atmosphere."

Rainfall of the Hawaiian Islands.—Mr. C. J. Lyons, the Director of the Hawaiian Weather Bureau, has recently published a pamphlet giving the results of the rainfall observations at 80 stations in the Hawaiian (or Sandwich) Islands.

The collection of rainfall statistics on the part of the Government commenced in 1890. A number of private individuals had, however, prior to that period established rain-gauges of their own, and several series of records of more or less continuity were available. These were collected and tabulated by months and years in the first pamphlet issued by the Weather Bureau. Rain-gauges are allotted to persons who are willing to make returns; many of the sugar planters, however, have provided their own.

The monthly publication of rainfall began in the Honolulu papers in 1892. The annual reports, beginning with 1892, have also contained monthly rainfall. Nearly all the stations established prior to 1897 are included in the tables.

It has been the rule of the Bureau from the first to make the daily measurement in the morning as early as convenient, presumably, as most observers are early risers, at six o'clock, and to enter as on the date of observations, and not for the day before. The subject was well considered, and decided thus, partly because, on account of the fact that a large proportion of the lighter rains fall at night, country observers naturally repair to the rain-gauge in the morning; and also that where other observations are made it is best to put everything down when observed.

Exposure to prevailing winds, and elevation above sea-level, are the two determining factors regulating the relative amount of rainfall at different stations. It must be remembered that the Trade winds, which blow on an average 260 days in the year, are from the direction of about N. 52° E., but are locally deflected by the trend of the coasts and slopes of the mountains. The heaviest rains are where the winds blow from the sea up the face of the mountain.

The South-westerly winds are most prevalent in the winter season. Where both winds are felt, the heaviest rains occur in February and November.

Where the South-west wind has less effect, March and November have the heaviest rainfall. The Trade wind varies in direction in some seasons; so when North-north-east winds prevail Honokau has the heavier rains, and when East-north-east winds are frequent Kapoho exceeds the usual amount.

The Kona or west district of the island of Hawaii is exceptional, being in the lee and depending on the sea-breeze for rain effect. As this is strongest in summer, the heavier rains are in July and August.

RECENT PUBLICATIONS.

Annales de l'Observatoire Municipal, Ville de Paris (Observatoire de Montsouris), publiées trimestriellement sous la direction des Chefs de Service. Tomes I. and II. 8vo. Paris, 1900-01.

The Montsouris Observatory has published the results of the meteorological, chemical, and other work carried on in the Observatory from 1872 to 1899. The publication, however, did not show clearly what new investigations were being carried on. The Corporation of the city of Paris therefore decided to issue a publication in octavo to come out every three months, giving without delay the results obtained in the various branches of the Observatory.

The first volume contains the results of the work done in 1899, in order that there may be no interruption in the records. In the volumes which are to follow, the researches of the current year will be dealt with.

The *Annales* of the Municipal Observatory will contain the official reports concerning the Observatory, the results of the researches made in the different branches, the original work of the staff of the Observatory, and the analysis of investigations of the same nature published in other works.

Deutsche Ueberseeische meteorologische Beobachtungen gesammelt und herausgegeben von der Deutsche Seewarte. Heft XI. Meteorologische Beobachtungen in Deutsche Ost-Afrika. Gesammelt und vearbeitet von Dr. HANS MAURER. 4to. 1902.

This volume contains the meteorological observations which have been made at 33 stations in German East Africa. The observations have been taken three times daily, viz. 7 a.m., 2 p.m., and 9 p.m. They are, however, not all for the same period, some starting in 1894 and others not till 1898, while in some cases they are not continuous. The figures give a useful representation of the meteorological conditions of a large district for which few data are available. By the publication of these observations accompanied by full particulars of the stations and instruments, the Deutsche Seewarte has rendered a great service to meteorologists.

International Catalogue of Scientific Literature. First Annual Issue. F. Meteorology, including Terrestrial Magnetism. Published for the International Council by the Royal Society of London. 8vo. xiv. + 184 pp. London. Vol. VI. 1902 (October).

The *International Catalogue of Scientific Literature*, commencing with the literature of the year 1901, is an outgrowth of the *Catalogue of Scientific Papers*, relating to the scientific literature of the nineteenth century, published by the Royal Society of London. The supreme control over the Catalogue is vested in an International Convention which meets every five years; and in the interval the administration of the Catalogue is vested in an International Council, the

members of which are appointed by the Regional Bureaus. The materials out of which the Catalogue is formed are furnished by the Regional Bureaus.

The branches of Science included in the Catalogue are the following :—

A. Mathematics.	G. Mineralogy.	N. Zoology.
B. Mechanics.	H. Geology.	O. Human Anatomy.
C. Physics.	J. Geography.	P. Physical Anthropology.
D. Chemistry.	K. Palæontology.	Q. Physiology.
E. Astronomy	L. General Biology.	R. Bacteriology.
F. Meteorology.	M. Botany.	

Each complete annual issue of the Catalogue will thus consist of 17 volumes, the price of which is £18. Individual volumes will be sold at prices varying with their size from about 10s. to 35s.

A Schedule of Classification and an Index thereto is prefixed to each volume in English, French, German, and Italian.

The present volume consists of three parts :—(*a*) Schedules and Indexes in four languages ; (*b*) an Authors' Catalogue ; (*c*) a Subject Catalogue.

The Subject Catalogue is divided into sections, each of which is denoted by a four-figure number between 0000 and 9999. The first or last of these Registration numbers is repeated at the head of the page. In the Authors' Catalogue the Registration numbers are placed within square brackets at the end of each entry, and so serve to indicate the scope of each paper indexed.

The general classification adopted in the volume for Meteorology is :—

Methods of Observation and Computation.
Observatories and Instruments.
Physics of Atmosphere :—
  General.
  Cosmical Relations.
  Optical Phenomena.
  Atmospheric Pressure.
Temperature and Radiation :—
  Atmospheric Temperature.
  Earth Temperature.
  Sea Temperature.
  River and Lake Temperature.
  Solar Radiation.
  Terrestrial Radiation.
Aqueous Vapour and Rain :—
  Vapour.
  Rain.
  Hail, Snow, and Frost.
Wind :—
  Wind.
  Constant and Local Winds.
  Periodical Winds.
  Storms.
  Cyclones and Anticyclones.
Atmospheric Electricity.
Climatology and Weather :—
  General.
  Weather Forecasting.
  Meteorological Registers.
Terrestrial Magnetism. The Compass. Earth Currents.

The Catalogue, which is very clearly printed, is likely to be a most valuable work of reference.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. August—November 1902.

The principal articles are :—"Photographische Aufnahmen des Sonnenring-Phänomens vom 13 März, 1902, zu Potsdam" : von A. Sprung (4 pp.). This is a description of a brilliant halo with 2 parhelia illustrated by a photograph.

"Zum Klima von Pará" : von Prof. Dr. Emil August Goeldi (19 pp.). This is a long and very interesting paper on the climate of Pará, based on 6 years' observations. Dr. Goeldi goes into great detail as to the action of the climate on the inhabitants. Among the greatest inconveniences is the constant damp, producing mould on books and clothes. The author gives a vivid picture of the intensity of the sun's rays, producing a constant flickering over the landscape. He remarks that the sun in the afternoon is more oppressive than in the morning. He distinguishes two seasons : the dry, or summer, and the wet, or winter, the advent of the latter being hailed by a chorus of millions of frogs. The entire paper merits translation for some journal which can afford space for it.

"Die tägliche Bewegung der Luft über Hamburg" : von Prof. Dr. J.

Schneider (6 pp.). This is a discussion of 10 years' anemometrical work at Hamburg. The author divides the winds into West and South, and finds that the West winds reach their greatest velocity about 1 p.m., and the South winds at 11 a.m. The mean velocity ranges for West winds from 2·8 to 5·2 miles per hour; for South winds from 0·3 to 3·0 miles per hour. The mean daily changes of velocity come out quite clearly in each year. The oscillations are not regular. The vane moves either to East or South in 10 hours, but requires 14 hours to return. A particle of air over Hamburg moves in a closed curve, which is egg-shaped.

"Der Platzregen im mittleren Maas-und in Roergebiete vom 30 Juni, sowie die Dauer-regen in Westdeutschland und Belgien vom 14 und 15 September, 1901": von Dr. P. Polis (7 pp.). This is an account of two very heavy falls of rain on June 30 and September 14-15, 1901.

"Weitere Beiträge zum Höhenklima des Staates Minas-Geraes Brasilien": von Prof. F. M. Draenert (18 pp.). This is another of Dr. Draenert's useful contributions to the climate of Brazil. The chief stations are Theophilo Ottoni, Arassuahy, and Diamantina. The maximum temperature is in December, the minimum in July. The climates of the two first-named stations are distinctly tropical. Diamantina is the most elevated station, but for it there are only one year's observations. The paper does not allow of being condensed. The elements discussed are vapour, rain, evaporation, weather, wind, and pressure.

"Beiträge zur Kenntniss der Wolkengeschwindigkeit. 1. Tägliche Periode der Wolkengeschwindigkeit": von Dr. P. Polis (13 pp.). Dr. Polis has taken the trouble of determining the cloud velocity, not only at Aix-la-Chapelle but also at other cloud stations. He gives the following results:—1. The upper and middle clouds travel fastest at mid-day. 2. This phenomenon is most marked with anticyclones and in warm weather, but in cold weather this diurnal march is frequently reversed. 3. The velocity increases with altitude. 4. Not much relation between altitude and velocity is shown by the upper clouds in cold weather and also under cyclonic conditions. 5. The Upsala observations show that *cirro-cumulus* and *alto-cumulus* do not agree in diurnal march; the former reaches maximum velocity between noon and 2 p.m., the latter between 4 and 6 p.m. 6. The lower clouds in Europe have an opposite march, and the velocity decreases towards the afternoon. 7. The daily period for *cumulus* is most marked. They move most rapidly in the morning and evening, and are slowest in early afternoon. This is most regular in warm weather and anticyclonic conditions. 8. The altitude of the lower clouds has a daily period. It is greatest at the warmest part of the day. 9. With *cumuli* the base moves more rapidly than the top. 10. *Strato cumulus* and *nimbus* show no regular march of velocity. 11. All clouds move more rapidly in winter and with cyclones. 12. The upper and middle clouds show a general agreement in velocity through Europe. For *cirrus* it is about 22 metres per second (say 49 miles an hour). The velocity of lower clouds is governed by local conditions. 13. At Upsala the mean altitude of upper clouds is greatest with anticyclones and cold weather. 14. The altitude of middle and lower clouds shows the reverse relation, and there is little seasonal difference.

"Kimmtiefen-Beobachtungen": von Karl Koss (7 pp.). This is an account of the observations of altitude of the horizon on board the Austrian ship *Pola* in the Red Sea.

"Ueber die Messung der Lufttemperatur auf dem Brocken": von W. Brennecke (4 pp.). This is a careful account of the great difficulty in determining air temperature when a Stevenson screen is snowed up.

"Ueber Emission und Absorption der Wärme und deren Bedeutung für die Temperatur der Erdoberfläche": von Nils Ekholm. This is a continuation of Dr. Ekholm's paper in the January number. In this part he deals first with

the determination of the absorption by means of carbonic acid, and secondly its determination by means of aqueous vapour. The paper is to be continued hereafter.

Among the "Kleinere Mittheilungen" are two remarkable notices: one by Taudin Chabot on a peculiar effect of refraction at sunset under the conditions of a volcanic disturbance of the atmosphere, when the sun set on June 25, 3′ 50″ *north* of its position on June 24. The observations were taken in Central America. The other is by Dr. Láska of Lemberg, as to the possible connection of humming of telegraph wires with impending changes of weather.

Natural Law in Terrestrial Phenomena. A Study in the Causation of Earthquakes, Volcanic Eruptions, Wind-Storms, Temperature, Rainfall, with a Record of Evidence. By WILLIAM DIGBY, C.I.E. 8vo. xlv. + 370 pp. London, 1902.

The author says that possibly this work might commend itself more readily to students of meteorology and to the public at large if he were a recognised authority in meteorological science. He states that he is, however, merely a humble student of natural phenomena. During a long residence in Ceylon and India he became interested in astronomy and meteorology, and studied the physical and economic causes of the famines of our Eastern Empire. Subsequently he became acquainted with Mr. Hugh Clements and his system of weather-forecasting, and was so captivated by it that he has written this book in support of Mr. Clements's theory. In brief outline, Mr. Clements's theory may be thus stated in his own words: "The movements of the air are controlled by the moon and the sun jointly; but, by comparing the air-pressures for a number of days at or near the same time of the year, I am able to eliminate the sun's influence and to produce my curve, showing air-pressure for a considerable period ahead, solely upon the moon's movements. With the necessary weather-records for past years in my possession for examination, the same calculations that I use for predicting a barometric curve for London could be used for any spot on the earth's surface."

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien. Mathem.-naturw. Classe. Bd. CXI. Abth. IIa. Mai 1902. 8vo.

This publication contains a paper by Dr. J. Hann, entitled "Zur Meteorologie des Aquators, nach den Beobachtungen am Museum Goeldi in Pará" (69 pp.). This paper is based on the observations of Dr. Goeldi at Pará, for the western side of the Atlantic, and on various records from the Congo State and other stations in Africa. The extraordinary equability of the Pará temperatures is very remarkable, the range in monthly means being only 2°·5 (1°·4 C.) throughout the year. The observations of Soyaux on the Gaboon are taken. The monthly mean range is nearly double, and while Pará has only one wet and one dry season, the Gaboon has two of each. The different elements are then discussed in detail, and observations from St. Thomas are also taken into account. The paper merits very careful study.

Symons's Meteorological Magazine. Edited by HUGH ROBERT MILL, D.Sc., LL.D. October—December 1902. 8vo.

The principal articles are:—"Meteorology at the British Association Belfast Meeting, 1902" (15 pp.). Several of the papers which were read at this Meeting are given *in extenso* or in abstract, viz. (1) "Report of the Committee on the Investigation of the Upper Atmosphere by means of Kites, in co-operation with a Committee of the Royal Meteorological Society"; (2) "The Rainfall of

Ireland," by Dr. H. R. Mill; (3) "Address to Sub-section of Astronomy and Cosmical Physics," by Prof. A. Schuster; and (4) "Radiation in Meteorology," by Dr. W. N. Shaw.—"The Maidstone Hailstorm of September 10, 1902" (2 pp.). The main feature of the storm at Maidstone was the size and amount of the hail, which, coming at the time when hop-picking was at its height, did great damage, entirely destroying the hop-crop in some gardens, and causing much discomfort to the hop-pickers.—"The Moon and Rainfall," by W. Ellis (1 p.).—"The Climate of Pemba in 1901" (1 p.). This contains the monthly results of the meteorological observations taken by Mr. T. Burtt at Banani, in the island of Pemba, on the east coast of Africa.—"Continuity in Observations" (2 pp.).—"The Moon and Thunderstorms," by V. Ventosa (1 p.).—"An Old Scottish Weather Record" (4 pp.). The Scottish History Society has recently printed for the first time a diary kept by Mr. Andrew Hay of Craignethan, a country gentleman of the seventeenth century. It is merely a fragment, one surviving note-book out of a series which has been lost sight of, and it covers only the period from May 1, 1659, to January 31, 1660. At the end of the notes of each day Mr. Hay gave a terse characterisation of the weather. The notes on the weather are reprinted in this article.—"The Meteorological Equipment of the Scottish Antarctic Expedition," by R. C. Mossman (3 pp.).—"Colonial Meteorology," by J. R. Sutton (1 p.).

Wind Velocity and Fluctuations of Water Level on Lake Erie. Prepared under direction of WILLIS L. MOORE, Chief U.S. Weather Bureau, by ALFRED J. HENRY, Professor of Meteorology. W.B., No. 262. Bulletin J. Washington, 1902. 4to.

Heavy Westerly winds over Lake Erie pile up waters in the harbour of Buffalo and lower the water at the mouth of the Detroit River, to the detriment of navigation, especially in the narrow dredged channel at the mouth of that river. This report by Professor Henry deals with the character and frequency of the storm winds that prevail on Lake Erie, the changes in water-level produced by them, and the possibility of predicting the occurrence of the most pronounced changes in level at the eastern end of the lake. The diagrams which accompany the report show the hourly fluctuations of the lake level at Buffalo and Amherstburg, and the hourly force and direction of the wind at Buffalo, from December 1, 1899, to November 30, 1900.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest. For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

Amundsen, Roald.—Expedition to the North Magnetic Pole. *Geog. Jour., London,* **20** (627-629).

Anders, H. S.—The Relation of Sunshine to the Prevalence of Influenza. *Jour. of Balneology and Climatology, London,* **6** (264-270).

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THE METHOD OF KITE-FLYING FROM A STEAM-VESSEL, AND METEOROLOGICAL OBSERVATIONS OBTAINED THEREBY OFF THE WEST COAST OF SCOTLAND.

By WILLIAM HENRY DINES, B.A., President.

[An Address delivered to the Royal Meteorological Society, January 21, 1903.]

THE idea of using kites to obtain meteorological data is one of long standing, having, so far as is known, been put forward by Dr. Alexander Watson of Glasgow in 1749.[1] In 1883 Mr. Archibald used kites to discover the change of wind velocity with elevation, but the credit of inaugurating the method, so extensively used during recent years in most civilised countries excepting England, is undoubtedly due to Mr. Rotch, who also pointed out the advantage that could be gained by using a steam-vessel for the purpose.

In the spring of 1901 a committee was appointed by this Society for the purpose of making, if possible, an investigation on the same lines in England, and the British Association, at their Glasgow meeting, also appointed a committee to co-operate in the work. At the request of this joint-committee, I undertook to carry out the experiments, and kites were flown almost daily for the months of June, July, and August 1902, at first from a land station, and afterwards from the deck of a small steam-tug, at Crinan, on the West Coast of Scotland. The reasons for choosing this locality were threefold. Firstly, because during the summer months there is not generally sufficient wind for kite-flying, and therefore it was desirable to choose the district in which, as a rule, the wind is strongest. Secondly, it was thought that it would be of interest to obtain observations of the temperature and humidity in the free air somewhere near Ben Nevis, and at the same level. Thirdly and chiefly, because nothing whatever was known about the temperature

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxiv., p. 250.

gradient over the ocean, and for Westerly, which are the prevailing winds, observations on the West Coast are equivalent to observations over the Atlantic.

The apparatus necessary to raise a kite a few thousand feet is simple and inexpensive, since a small kite and fine wire may be used, and no motor or steam-engine is necessary. I think that any one with a little mechanical ingenuity might, apart from the recording instruments, fit up

Fig. 1.—Crinan Harbour from the Tug.

such an apparatus for £10 or £15; but if it be desired to reach heights exceeding 4000 or 5000 ft. a much more extensive outfit is required.

The following articles are necessary:—

1. Winding-in apparatus.
2. Petrol motor or steam-engine.
3. About six miles of wire, preferably in one piece.
4. Six to twelve kites.
5. Recording instruments.

The following is a description of the apparatus used at Crinan:—

Winding-in Apparatus.

Unfortunately it is not feasible to wind a great length of wire under tension on any ordinary reel, for the reel, unless it is enormously strong, and therefore of a prohibitive weight, is crushed out of shape by the strain. It is necessary to reduce the tension of the wire before it is wound, and this, although easy enough in the case of string, leads to complications in the case of the hard and springy steel wire that is used for kite-flying.

The apparatus, the principle of which is shown in the diagram (Fig. 2), is the result of many modifications and experiments, and seems now to be quite satisfactory. The wire W, on coming from the kite, passes over

the pulley A, of 8 inches diameter; it then goes down the centre of a piece of iron tube on which the pulley is mounted, this tube turning inside another tube which is fixed to the frame of the apparatus. By this means the horizontal axis of the pulley is movable about a vertical axis, and the wire can leave the apparatus in any direction whatsoever. The wire next goes under the pulley B. This is mounted on the end of the lever C, and from the other end of the lever C a wire cable, Z, goes to the hook of an ordinary spring balance, the pulley and lever thus forming a convenient dynamometer. On leaving the pulley B the wire goes round the drums D and E about twelve times in a series of figures 8, and one of these drums, it does not matter which, is driven by a chain from the steam-engine.

The drums are 16 inches diameter, but 12 inches would probably suffice. On leaving the drums the tension of the wire is reduced to 1 lb.

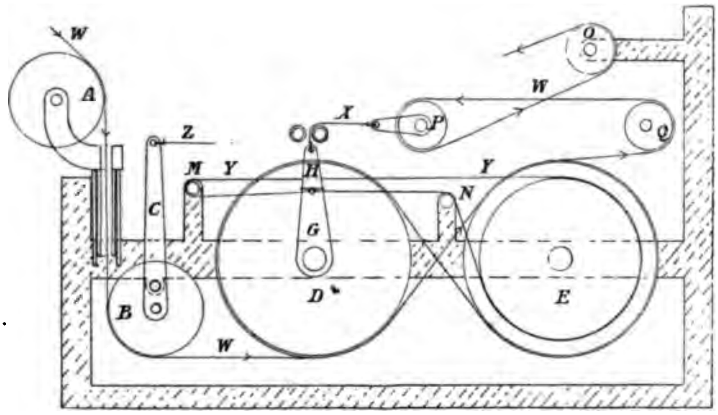


FIG. 2.—Winding Gear.

or less, even though it may have amounted to 200 lbs. before reaching them, and it is now ready to be wound on the storage reel. This is 16½ inches diameter, 4 inches wide, and has a rectangular groove 3 inches deep (not shown). It is formed of an ordinary wooden pulley, with two sheet-iron discs screwed on, one on each side. It runs loose, and can slide longitudinally on the axle of one of the drums. It is actuated thus. A lever, GH, is provided, so that when the end H is thrown over to the left the reel slides along the axle, and its periphery is pressed against the periphery of the moving drum. When the lever is thrown over to the right the reel slides back, and its periphery is pressed against the fixed frame of the apparatus. The lever is on the left when the wire is coming in, on the right when it is going out. The tension is regulated thus. The lever being well over to the left, the reel turns with the drum, and since it is larger than the drum it is in contact with and round which the wire is passing, the wire is wound on it more quickly than it is delivered, and soon becomes tight. As soon as this occurs the lever is automatically drawn back towards the right, the pressure, and therefore the friction, between the drum and the reel is reduced, the wire is not wound on so quickly and tends to become slack. Thus, automatically,

the wire is wound on the reel under a light and uniform tension. When the wire is running out there must of course be a brake on the reel, and the lever must therefore be on the right hand.

At first the lever was shifted by hand, but it is now done automatically, a much more satisfactory arrangement, since the machine never forgets, a thing which the human agent did sometimes do. The end of the lever is secured to an endless wire cable, Y, passing round the drum E and over the two small pulleys M and N. The friction between the drum and the cable lying on it is sufficient to move the lever backwards and forwards, to the right when the wire is running out, to the left when it is being wound in. The lever GH is drawn towards its central position, and the tension of the wire reduced in either case as follows:—The wire, on leaving the drum E, goes over a movable pulley, Q, thence over a movable pulley, P, thence to another fixed pulley, O, and thence to the reel. The pulleys are all of 4 inches diameter; P and Q slide on a rod (not shown in the diagram), and are kept apart by falling weights, but are drawn together by the wire when it becomes tight. A cord, X, is easily arranged to run from P to the end of the lever, so that as soon as the wire is tightened, and P and Q are drawn together, the lever is drawn to its central position. In any case this relieves the tension, for if the wire is running out, it takes off the brake, and if the wire is being wound in, it decreases the friction between the reel and the drum which is driving it. These pulleys P and Q also perform the useful purpose of taking up any slack that may occur. As an additional precaution a friction-clutch (not shown) is provided to lock the reel against running out. This cannot act when the wire is being wound in, and in ordinary use it is held off the reel by the tension of the wire; but should this tension become too greatly relaxed, the clutch is let fall and locks the reel.

I do not know what trouble others who have worked with kites may have had with their winding-gear, but complaints as to the difficulty of handling the steel wire are common. This difficulty arises from the tendency of the wire to twist and form a kink. A kink once formed, the piece of wire in which it is is useless, and the only certain preventative is to keep the wire taut. No precaution to secure this end should be neglected, and hence an elaborate and somewhat complicated winding-gear is an unfortunate necessity.

It should be added that a revolution counter is connected with the pulley A, by which the amount of wire that is out is shown, and there is also an arrangement for distributing the wire automatically on the reel. Further, the wire cable Y which shifts the lever GH is kept tight by a spring, but the spring is relaxed and the cable slackened to prevent undue wear, when the wire between the drums and the reel becomes slack.

There is no pretence of giving the details; the general principle only is indicated in the diagram.

Motive Power.

Some source of power is necessary, for the winding in of several miles of wire by hand under a tension of 150 to 200 lbs. would be a very tedious process. It would also add to the risk of not recovering the

meteorograph and kites, for the longer they are in the air the greater is the chance that the wind may rise or fall, and render their recovery difficult or impossible. A petrol motor has the advantage of requiring no boiler, but on the whole a steam-engine seems to me far preferable. The process of winding in a kite is equivalent to increasing the wind velocity, and always adds to the strain upon the wire. On ordinary occasions this does not matter, but there are unavoidably times when to wind in too quickly means certain destruction to the kites or wire; yet, on the other hand, if the wind be rising, every effort must be made to get the kites in quickly. On such occasions a steam-engine, provided it has no dead point, will do automatically and smoothly what can hardly be done with a motor even by the most careful attention, for the engine takes advantage of every slackening of the strain to wind in rapidly, and slows down or even stops when the strain again increases. It thus gets the kites in in the shortest possible time by taking advantage of the lulls between the gusts.

A steam-engine is convenient in other ways. It can be used to help the wire out when the wind is light, and the tension too small to overcome the friction of the apparatus. It also serves as a brake; in fact, when it is combined with the winding gear just described, the person in charge has complete control over the kite, and can let it rise or wind it in either quickly or slowly, and can also change instantly from one to the other by using the reversing lever of the engine alone.

The Wire.

Eight miles of wire were obtained in one piece from Messrs. Brunton and Son of Musselburgh. It was of $\frac{1}{32}$ inch in diameter, and was capable of bearing a strain of from 250 to 300 lbs. Joining two pieces of wire is, according to most accounts, a troublesome process, but I have had no experience on this point, as the wire did not break save once or twice quite near the end, and no join was required. To make an eye on the end, a piece of brass tube about 8 inches long and of $\frac{1}{8}$ inch outside diameter is used. The wire is threaded through the tube, and about 4 inches are left projecting. The tube with the wire in it is then bent twice or three times round a piece of $\frac{3}{8}$ inch rod, and the projecting end of the wire twisted round and secured. This is very strong, as strong, in fact, as the wire itself, and is quickly made. It is not necessary to soften the end.

Mr. Rotch's arrangement for oiling the wire was provided, but was not used. It is more convenient to pour about half a tea-cup of oil over the reel on which the wire is stored every third or fourth time it is used. The oil is thoroughly disseminated over the drums and pulleys as the wire runs out, and every part of the wire coming in contact with these, it is well smeared all over before leaving the apparatus.

We did not use a swivel at Crinan. It only comes into use when the kite dives and turns completely over in the air, and with a good kite I doubt if it be worth its extra weight.

The Kites.

Undoubtedly a good kite is the most important of all the apparatus, and an ideal kite would possess the following qualities:—

1. Perfect stability in any wind.
2. It must fly with a short line at an angle exceeding at least 55°.
3. It must not exert too great a pull in any wind, however strong.
4. It should fly in a light wind.
5. Simplicity of construction.

Cheapness, durability, and portability are also desirable qualities.

I do not include the pull, because it is perfectly easy to obtain a larger or smaller pull by making a larger or smaller kite.

The kites used at Crinan are described in *Symons's Meteorological Magazine* for May 1902, and the description, for the sake of convenience, is, by the permission of Dr. Mill, reproduced here.

A New Kite for Meteorological Purposes.

Some brief description of a modified form of the Hargreave kite, which I hope may be found suitable for raising meteorological instruments, will perhaps be of interest to your readers.

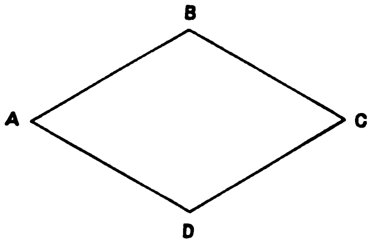


Fig. 3.—Section of Kite.
AB = BC = CD = DA = BD = 3 ft. 6 in.

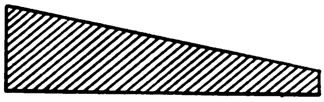


Fig. 4.—Section of Stick (actual size).

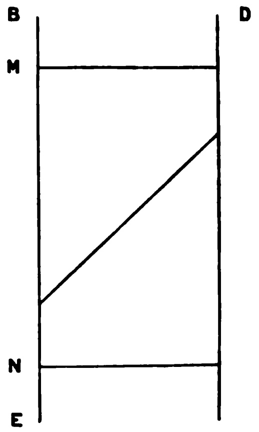


Fig. 5.—Frame of the Kite.
BD = 3 ft. 6 in. BM = NE = 1 ft.
BE = 7 ft. 6 in.

The kites used at Blue Hill seem to possess everything that can be desired in the way of stability and lifting power, but unfortunately they are tedious and expensive to make, and are not readily portable, and hence I have been trying various other forms in the hope of getting a cheap and portable kite equally powerful and stable. So far as my limited experience goes the following form seems to meet all requirements. The kite is of the cellular form, but the section of the cells is a rhombus (diamond-shaped) instead of a rectangle, the shorter diagonal being of the same length as each side (Fig. 3). Each kite has four longitudinal sticks of triangular section (Fig. 4), and 7 ft. 6 in. long. The two opposite sticks which lie at the ends of the shorter diagonal are connected by three cross pieces of the same material, and form the frame of the kite (Fig. 5), the ends of the cross pieces being carefully spliced to the sticks. This is accordingly the size to which the kite will fold up, viz. 7 ft. 6 in. by 3 ft. 6 ins. by 1 or 2 ins.

Two pieces of cloth are then prepared, both being 14 feet long, one 28 and the other 31 inches wide. (This difference of width is in accordance with Mr.

Rotch's recommendation.) The ends are sewn together, and a hem, inside which strong twine is placed, is run round each edge. The narrower of these pieces forms the upper, and the wider the lower cell of the kite. The pieces are now marked out by four lines drawn with a coloured pencil on the material, at equal distances of 3 ft. 6 in. apart, and the material is secured to the sticks along these lines. This is done by laying it over the sticks and placing on it a strip of thin wood, which is then nailed on with light brass tacks. To spread out the kite it is only necessary to separate to the greatest possible extent the two loose longitudinal sticks. This is done by means of two bamboos. The bamboos when in place, are secured by string to the cross pieces of the frame, over which they lie at right angles.

The bridle can now be secured, and the kite (Fig. 6) is ready for use, having taken, apart from the sewing, only a few hours to make. It should be added that the part of the front stick where the bridle is fastened is stiffened by

Fig. 6.—Rhomboidal Kite.

splicing to it a piece of wood about 18 in. long, and also the edges of the cloth cells are kept apart midway between the sticks by light pieces of wood of about $\frac{3}{8}$ in. square section, and of lengths equal to the width of the cloth. The ends of these pieces slip into small pockets sewn on for the purpose.

A kite of the dimensions given above will weigh about $6\frac{1}{2}$ or 7 lbs. It will fly at an elevation of from 55° to 60°, and exert a pull of from 40 to 80 lbs. in a suitable breeze. It can be got up in a wind of from 8 to 10 miles per hour, but no opportunity of determining the greatest wind velocity at which it will fly has occurred as yet. Indeed the wind a few hundred feet high is here (Oxshott), at all events, very different to that prevailing at 50 feet, and without an anemometer attached to the kite it is impossible to estimate its velocity.

It may be mentioned incidentally that flying these kites at a height of 500 feet has shown the existence of alternating upward and downward currents at that height, for a kite will fly at an elevation of 50° to 55°, and then without any change in the steadiness or pull on the wire fly at an angle of 70°, or even 75°, for some minutes, a change that can only be produced by the varying angle of the air motion.

The steadiness and angle of these kites is very dependent upon the arrangement of the bridle and point of attachment of the line; 14½ inches downwards from the top and 5 inches outwards in front of the stick seems to be the most suitable place, but this may be modified by subsequent trials.

The following remarks may be added to the above description:—

The upper bamboo should have a diameter of not less than ⅞ inch; the lower may be lighter, about ⅝ seems sufficient. The point of attachment may be from 14 to 15 inches down, and quite close to the front stick. The stability seems as good and the pull more uniform than when it is 5 inches in front of it. Kites apparently just alike vary in their stability, and this is seemingly due to slight differences in the tightness of the string in the seams. A slack string in the upper seam, *i.e.* in the edge first struck by the wind, will utterly spoil the kite, but on the other hand it must not be too tight, or it puts too great a strain on the sticks, and equally spoils the stability. I think no fault can be found with the stability of these kites, for we never had any trouble with winding them in to, or starting them direct from, the winding-gear. We also often used to tie a kite with some 20 ft. of cord to the rail of the vessel while the clamp to secure it to the line was being put on, and although at first the second and third kites were attached with some 200 ft. of cord, this was gradually reduced until it came to about 20 ft.; neither with this short length did the kites ever dive and foul the main line.

The angle at which these kites flew, with a short length of wire, ranged between 60° and 65° on every occasion on which the wind exceeded a light breeze. For purposes of comparison a table is given below, the means being based upon every observation made at Crinan:—

Average Values.

Length of Wire Out.	Angular Elevation of Kite.
250 ft.	62° 30′
3000 „	45 0
4500 „	39 0
5500 „	39 30
6500 „	34 40
7500 „	34 30

Best Results ever recorded.

Length of Wire.	Pull.	Angle.
250 ft.	20-80 lbs.	65°
1300 „	120 „	62
5450 „	80 „	50
5700 „	60 „	51
6200 „	50 „	41
7750 „	35 „	38
8700 „	30 „	37
9730 „	50 „	36

It must be borne in mind that a kite can only be tested for the goodness of its angle with a short length of wire. With much wire out the angle depends on the relative sizes of the kite and wire; with a large kite and a fine wire, a good angle, and consequently a great height may be

obtained, but concurrently with this goes an increasing risk of breaking the wire.

It is noteworthy that when the kite was thoroughly wet the angle was best, although the weight was 2 or 3 lbs. greater.

With regard to the third qualification, namely uniformity of pull, there is plenty of room for improvement. In a strong breeze the kite exerted a pull of 100 lbs.; one was drawn in from a distance of 4000 ft. against a pull ranging from 150 to 200 lbs. It is very desirable that a kite should be designed that is incapable of exerting a pull of more than 50 lbs., but that is capable of giving 30 or 40 lbs. in a moderate breeze. The pull may be reduced by shifting automatically the point of attachment upwards, and this is easily arranged, but this shifting is apt to spoil, or at least to decrease the stability.[1]

With reference to the fourth qualification, namely power to fly in a light breeze, much misconception exists. I have repeatedly flown a kite at Oxshott in a wind that, at 50 ft. above the surface, has not exceeded 5 miles per hour; but I know perfectly well, from my experience at Crinan, that at least 10 miles per hour is requisite there. Inland the wind at the surface is very different to what it is above, and if there be sufficient wind at a few hundred feet elevation, a kite can generally be got into it.

Probably most kites begin to fly with a wind between 8 and 12 miles per hour, but as about 10 miles per hour is the average for the South-East of England, the difference between the capabilities of flying at these two velocities is an important one.

The other qualities call for no special comment; but a kite cannot be too simple, for every additional piece or stay gives additional chance of a failure or breakage, which may lead to the loss of the meteorograph and wire.

Necessary Attendance.

In addition to the apparatus, in ordinary circumstances an expensive part of the work is the attendance that is necessary. Mr. Rotch, the great authority on kite-flying, states that at least three skilled persons are required, and the result of my experience, save under the most favourable circumstances, is the same. In good weather two can manage, perhaps even one, but then no notes can be made. It is sufficient work for one person to attend to the engine and winding-gear; another should be responsible for the notes relating to the wind direction, clouds, height of the kite, etc.; but the necessity for three arises when a kite has to be attached to, or taken from, the main line. It is only exceptionally that this can be done by less than two. One of the three at least should be able to carry out the small repairs to the kites, engine, winding-gear, etc., that may become necessary, and one must be able to use a sextant or clinometer, and change the sheets of the recording instruments. If these offices are interchangeable, so much the better.

I must here express my indebtedness to my two sons, without whose assistance it would have been impossible for me to have carried out the

[1] Since the above was in type, a great improvement in this point has been brought about by some modification of the details. Also by the use of a strip of the same material as the sails instead of string, the difficulty caused by the unequal stretching, and unequal shrinkage with wet, of the sail and the string in the seam, has been avoided. The rigid frame has been done away with, and the kites are now made to fold up completely.

work, and also to Captain Hepworth, who kindly spent a fortnight at Crinan and helped in many ways, especially with regard to the vessel.

Self-recording instruments were sent up on every occasion when the wind was strong enough. They were hung from the wire about 200 ft. below the kite, and consisted of a self-recording aneroid to give the height, a thermograph, and a self-recording hair hygrometer. It is well known that heights determined by an aneroid are to some extent doubtful, and so we found it. The thermograph appears to have been entirely satisfactory. The hygrometer often gave instances of over-saturation, but this can hardly be wondered at, since the bundle of hairs on which its record depended was frequently covered with drops of water, and at times was unavoidably wetted by the salt spray.

The meteorograph weighed 3 lbs., and with very light winds could not be sent up. On such occasions an arrangement consisting of a pair

FIG. 7.—Base Station at Crinan.

of test tubes, which will be described elsewhere, was sent up in the kite, and gave the temperature at the highest point reached.

The Meteorological Council kindly lent the necessary instruments, and bore the expense of keeping up a Second Order Station at Crinan during the time of the observations, for which I must here, on behalf of the Kite Committee, express our indebtedness.

Kite-flying from a Fixed Station.

The apparatus which has just been described was placed on the highest point, about 50 ft. above sea-level, of a small rocky island in Crinan Bay. The ground sloped precipitously to the sea within about 30 ft. of the winding-gear on the south-east side, but two ridges extended about 200 yards, one to the north-east, and the other to the north-west. In this latter direction lay an open expanse of sea, and a wind from this

quarter, if strong enough for kite-flying at all, was strong enough to start the kite direct from the reel. To the south and west there were high hills, and special means had to be employed to start a kite when the wind

FIG. 8.—Small Island from which Kites were flown.

was light from any point between South-east and West. The wire with the kite attached, was taken out to the extremity of one of the ridges, and the person holding it signalled by waving a handkerchief at the first

FIG. 9.—Winding Gear, Steam Boiler, etc., on Island.

favourable opportunity. It was then wound in with the utmost speed of which the engine was capable, and seldom failed to rise sufficiently into the upper and stronger current to get a fair start. We could generally discover if there were sufficient wind above by the appearance of the open sea.

Some care is required in getting in a kite in a light breeze, since if it is drawn in too rapidly it will probably pass right overhead and dive down on the windward side. This is particularly the case with Mr. Cody's kites. It is well never to allow the altitude to exceed 75°.

Steam-Vessel.

A small steam-tug, the *Countess*, was hired from July 8 to August 28 from Messrs. Macleod and Sons, Alloa. She was 55 ft. long, 14 ft. 6 ins. beam, and of 50 nominal horse-power. She could steam about 7 knots, and was a safe and convenient boat. Between the funnel and the towing-rail there was a space of 14 ft. by 13 ft. In this the kites were stored, and put together as they were required. As it was not possible

FIG. 10.—The *Countess*.

to get them into the cabin, they had to be kept on deck and protected from the weather by a tarpaulin. Behind the towing-rail there was just room to place the winding-gear, which was bolted down to the deck, a very necessary precaution. There was sufficient space, but not more, to pass comfortably between it and the rail of the vessel. The steam boiler was not required, since steam for the engine was taken from the boiler of the vessel. Thus it will be seen that the space in which the kites had to be put together, and from which they had to be started, was decidedly limited; but in one way, I think, the smallness of the tug was an advantage, for the eddies in the wind produced by her were of little consequence. I am very doubtful whether, with a larger vessel, it would or would not be a better plan to put the winding-gear in a deck-house and pass the wire out through a hole in the roof. We had great trouble in protecting the wire from rain and spray in bad weather, and this would not occur if the apparatus were sheltered; but on the other hand, it is certainly desirable that the person in charge should have an uninterrupted view of what is going on. The vessel had no masts, so that the only things to be avoided were the funnel and the funnel stays. She was suitable for the purpose in every respect save that of speed. An additional 3 knots would have

made a very considerable difference in the heights attainable in calm weather.

Kite-flying from a Vessel.

Kite-flying from a small steam-vessel with a single kite is a very easy process. The use of a vessel gives one the power of adding to or subtracting from the wind's velocity the maximum velocity of which the vessel is capable. Thus, if she can steam at a rate of 7 knots (8 miles) per hour nearly, and the kite will fly well in any wind between 12 and 30 miles per hour, the use of the vessel extends these limits to 4 and 38 miles per hour. With a vessel steaming 12 knots, kite-flying would be

FIG. 11.—Stern of *Countess*.

possible in any wind less than a strong gale. The *Countess* could hardly manage 8 miles per hour, but a height of at least 1300 ft. was reached on every day she was available.

On calm days the vessel was taken into the open channel, and if it were so perfectly calm that there was not a ripple on the water, a kite could not be got up, since the unaided speed of the vessel was insufficient. As soon, however, as a ripple appeared the vessel was put full speed against the wind and the kite started. Wire was then paid slowly out, until the greatest amount consistent with its remaining clear of the sea had been let off the reel. This would generally be about 3000 ft. Under these circumstances the wire would leave the vessel almost horizontally, and the angle of the kite would not exceed 20° or 25°. As soon as it was plain that no more wire could be let out without its dropping into the sea, the winding-gear engine was reversed and the wire wound in as fast as possible. The angular elevation of the kite would rapidly increase, and also the actual height, to which it was often possible to add at least 25 per cent in this way.

With a good breeze for kite-flying, force 4 to 5, the vessel would be

kept stationary, while the kite was started. It and the recording instruments being fairly up, the vessel would be worked so as to keep a pull of about 30 to 40 lbs. on the wire. Generally this would mean going half speed against the wind, or full speed across the wind, while the wire was running out. For winding in the vessel would run before the wind, since by this means the process could be got over more quickly without putting an undue strain upon the wire. On such days one kite, under favourable circumstances, would take from 8000 to 10,000 ft. of wire, and lift the instruments to a height of about a mile.

On rough days various difficulties were encountered. The first was putting the kite together, but after a few occasions practice made this fairly easy. It was found most convenient to put the vessel with the

FIG. 12.—Starting a Kite.

wind on the beam, and to secure the bridle of the kite to the rail on the windward side. The bamboos could then be put in and the kite extended without much risk of breakage. So long as the bridle of a kite only is held it is fairly safe, but an attempt to hold any other part when a strong wind is blowing is almost certain to lead to damage. The eye at the end of the wire being secured to the bridle, the vessel would be turned so that she was nearly before the wind, and the kite released. It was more due to luck than skill that no kite ever fouled the funnel or stays during this process, and it is certainly a severe test as to stability to start a kite from a small vessel when the wind equals or exceeds force 6 on the Beaufort scale. The kite being started, the vessel would be put half speed before the wind and the wire let out slowly, a careful watch being kept meanwhile on the dynamometer. If the pull exceeded 80 lbs. the kite was not allowed to rise. The pull might be reduced by going full speed instead of half, but this would leave no margin for the inevitable winding in; and since, owing to the limited funds at the

disposal of the committee, we had no spare set of self-recording instruments or apparatus, it was not considered advisable to run any avoidable risk.

The chief trouble in rough weather was to protect the wire and recording instruments from spray. The wire is kept oiled, and simply wetting it with salt water does no harm; but to allow spray to fall on the reel, and then to wind on subsequent coils of wire, would probably lead to extensive corrosion. The winding-gear has now been altered so that it can be used with the cover on. Salt water is not good, apparently, for the hairs of the hygrometer in the recording instruments, and there was no place on deck where the instruments could be freely exposed to the air and yet protected from the spray.

Two or more Kites.

It is a difficult question to settle when it is advisable to put another kite on the line. After a certain amount of wire has been let out, ranging from 2000 to 10,000 ft., according to the wind, the wire as it leaves the reel becomes almost horizontal, and if any increase of height is to be attained another kite must be put on. Theoretically, when the whole length of wire that it is intended to use is out, the kites should all have the same angular elevation, for then the allowance for sag is the least. But since, under any circumstances that occur in practice, the correction for the sag of the wire cannot exceed 3 per cent, assuming a uniform wind right up, it does not make much difference in the height attained if all the kites are at the extreme end, or arranged uniformly along the wire. Practically, however, it is not a good plan to have the kites close together, for should any great increase of wind occur locally, if it affects all the kites at once, their combined pull is likely to break the wire; whereas, if they are a mile or so apart, there is a very fair chance that only one or two will be influenced at the same time, and that no harm will ensue.

At Crinan another kite was generally added when the angle at which the wire left the reel had decreased to 15° or 20°. This would be at various distances from the first kite, but on the average at about one mile. The third kite would be about 8000 ft. below the second, for with two kites the pull is greater, and more wire can be let out before the angle is decreased so much. It is probably better not to have too long an interval between the first and second kite, for on one occasion we put the second on at 9000 ft. below the first and then let out another 8000 ft. The wind decreased, and on recovering the second kite the wire beyond was found to be in the sea. Guessing what had happened, for it was a cloudy day and the kites could not be seen, we wound in as fast as the engine could do so, and finally, after drawing quite a mile of wire out of the sea, saw the first kite flying safely, but at a very poor angle owing to the light wind. Subsequently so great a length of wire was never allowed between the first and second kite.

Kite-flying with more than two kites on the line is very risky, even when one has the advantage of a steam-vessel. Since one kite of the kind used at Crinan may alone exert a pull of 200 lbs., and the wire breaks at 250 to 300 lbs., with three kites there is great risk that the

limit may be exceeded. Different layers of the atmosphere have different velocities; sometimes there is a very considerable difference, and if the upper kite gets into a stronger current, it may rise rapidly and draw up the second into the same current. If, then, the vessel be put before the wind so as to reduce the pull upon the wire, the wind is taken from the third kite, which hangs like a dead weight suspended by its cord from the main line. As the clamp from which the kite is hanging nears the vessel, the kite is almost certain to fall into the sea. It is fortunate if this happens near enough to the vessel to enable the cord to be cut before further harm is done. On the other hand, to stop the vessel adds to the strain, already too great, produced by the other two kites. On one occasion we got two kites into the sea in the way described above. One was completely broken by the waves, but the other was recovered but little damaged. This, and one kite that broke away owing to the fraying of the cord by which it was secured to the main line, were the only kites we ever lost.

On the occasion on which the instruments were lost, four kites were used and 31,050 ft. of wire. The second kite was put on at 5500 ft., the third at 11,500 ft., and the fourth at 25,800 ft. At starting the wind was light, and the vessel had to steam full speed against it, but during the time the wire was running out it increased. Finally the vessel lay to, and the four kites were almost in line, at an angle of about 28°, exerting a pull of 150 lbs. The end kite could just be seen, but could not be located in the sextant telescope. The last certain observation was with 28,050 ft. of wire, when the angle was 29°, giving a height of 13,500 ft. The instruments having been lost, the greatest height attained is doubtful, but it was probably a little under 15,000 ft. The angle of a kite is continually varying, and it is a great chance if a sextant observation coincides with the highest value; hence it is not unlikely that, when the greatest length of wire was out, the angle may have reached 29° or 30°, which give the corresponding heights of 14,850 or 15,350 ft. I believe, whichever estimate be taken, that this is the greatest height[1] ever reached with four kites. The vessel was put before the wind, and the wire wound in. Soon after the fourth kite was recovered, the end one became unsteady and dived violently, owing, as it subsequently appeared, to the string in the top seam being too slack. The wind was rising, but the third kite was recovered, and almost the second, when the cord by which the end kite was secured to the eye at the end of the line, doubtless frayed by the long strain, broke. The meteorograph, which had been attached 200 ft. below the kite, being left without support, fell of course into the sea, together with the wire to which it was fastened. The second kite, now the last on the line, was soon got in, and the wire carefully followed up. It was full of kinks, and was found to be broken about 1000 ft. beyond the second kite. Thus the instruments were lost. The end kite was recovered undamaged, floating in the sea about two miles farther on.

Had this kite been secured to the eye by wire cable instead of cord,

[1] The heights given in the *British Association Report* subsequent to July 19 are 3½ per cent too low. The revolution counter got broken on that date, and a new one had to be obtained. There was no opportunity of testing this until my return home, when, on trial, it was found to differ from the old counter, for which the diameter of the wheel had been adjusted, by 3½ per cent.

or had we noticed and rectified the slackness of the string in the top seam, or had we not let out so much wire with an obviously rising wind in a vain attempt to beat the record for height, the accident would not have happened. But it is easy to be wise after the event.

Clamp Used.

The attachment of a supplementary kite to the main line did not give the trouble that was anticipated. Cord was used for these kites, as it is so much easier to handle than wire. The kite was started in the usual way, and the cord paid out by hand. A clamp had meanwhile been put upon the main wire, to which the end of the cord was tied. At first

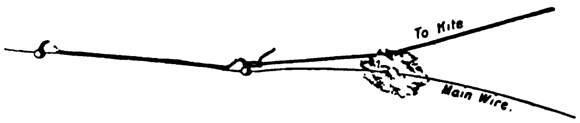


FIG. 13.—Clamp securing additional Kites to the Wire.

a length of 200 ft. was used, it being feared the kite might foul the wire. This was successively reduced to 150, to 100, to 50, and finally to 20 ft. The clamp was made of about 18 ins. of brass wire. The ends were enlarged, bent round, and sawn down with a fine saw. The wire was laid in one saw cut, then coiled spirally about five times round the brass wire, then placed in the saw cut at the other end. A nut and washer were then screwed down on the wire at each end. A piece of cotton waste was put round the wire just above the clamp, and a half hitch in the cord leading to the additional kite encircled the lump of waste and the wire. The clamp was very efficient. It did not take long to put on or to take off, neither did it injure the wire.

Time Required.

Apart from the time during which the kite was kept at its highest point, the period necessary to accomplish an ascent and to get back the kite was on the average about one hour for every kite used. This is the time counted from when the kite left the vessel until its recovery; it often happened that two or three hours more were spent in going to a suitable place for starting, or in returning from the spot where the last kite was got in. Thus two observations at a small elevation could be, and often were made daily, but if more than two kites were used there was not time for more than one ascent.

Meteorograph Heights.

All who have worked with kites have found that the meteorograph cannot be depended upon to give a true record of the height, and an incidental advantage of kite-flying from a vessel is the ease with which, on clear days, the meteorograph can be checked. Exact measurement is not easy on land, for in the ordinary way a kite is continually rising and

falling, and it is difficult to identify on the chart the precise moment at which an observation is obtained. When the exact distance of a kite is known, and also its angular elevation, its height is also known. The distance of the kite from the observer is given by the length of wire out, subject to a small and unimportant correction for the sag of the wire. At sea the angular elevation can be got with a sextant. Thus, when the kite can be seen, its height can be obtained with an error that ought not at the outside to exceed 2 ft. in every thousand. The only difficulty, therefore, is to locate on the chart the precise time at which the observation was made. If, however, it is known that the kite was rising before the observation and sinking after it, and that the observation corresponded to the highest point reached, there is no difficulty in the identification. On the sea this is easily accomplished, for in ordinary weather the kite can be raised or lowered at pleasure, without altering the length of wire out, by altering either the speed or the direction of the vessel. At Crinan observations of the height were frequently made, and the results show that heights given by the meteorograph were unreliable to the extent of about 5 per cent.

Locality of Observations.

There are very strong currents in the neighbourhood of Crinan, 6 to 8 knots occurring in several localities, both with the flood and ebb tides. At first these caused us much trouble, as the sudden falling off in the speed of the vessel, as she met the tide on a calm day, caused the kite to drop unexpectedly. Subsequently, when we knew the coast, the tide races were often utilised, and enabled us to get a few thousand feet higher than we could otherwise have done. With a South-west or North-east wind the locality was very convenient for kite-flying, but with a North-west or South-east wind, the long but narrow island of Jura prevented a clear run either with or against the wind. The gap between Jura and Scarba, well known to all who are acquainted with the coast as the Gulf of Corryvreckin, can only be utilised to a limited extent, as it is subject to a most violent tide race, and owing to the breaking of the sea, is considered unsafe in bad weather. About two-thirds of our ascents were made in the Sounds of Jura or Scarba, and the remaining third on the open sea to the south of Mull. From the meteorological point of view, kite ascents at Crinan with a wind anywhere from the West may be taken as equivalent to ascents over the Atlantic Ocean, for could any one have ascended with the kite, he would have seen the open sea extending to the westward, unbroken save for a few small islands.

It may be stated here that the motion of the vessel did not interfere with the stability of the kites in any way. The only trouble we had in rough weather was owing to the spray.

Results.

A considerable amount of information concerning meteorological phenomena has been obtained—71 observations of temperature at an average height of 4140 ft., and 38 charts from the self-recording instruments with an average of over 6000 ft. having been secured.

These are being dealt with by Dr. Shaw, and it may be stated here that the temperature gradient was less than the average, being about 1° F. for every 350 ft. of height; but there are several points of interest apart from the temperature gradient that may be mentioned.

The first is the steady motion of the wind over or near the sea when compared with that at an inland station. When flying a kite at Oxshott with only a short line, say 400 ft., it soon becomes apparent that small local upward and downward currents are very prevalent, for the angle of the kite is perpetually varying within wide limits, perhaps from 45° even to 80°, at least it is so during the daytime in the summer. With the same identical kite and the same length of line, during July and August, at Crinan, the angle never passed the limits of 60° and 65°, provided the breeze was strong enough to lift the kites properly. At both places convection currents are always associated with cumulus clouds, but at Crinan these currents were not noticeable at a less elevation than 1500 ft.

Another point that soon became apparent was the prevalence of a breeze at the mouth of Crinan Bay when it was a dead calm elsewhere. The coast line runs south-south-west and north-north-east on both sides of the bay, and hills of about 600 to 800 ft. elevation rise steeply from the shore. Thus Crinan Bay forms an opening of about a mile and a half wide in the range of hills, and the air seems to move through this gap when it is still elsewhere.

Another phenomenon occasionally noticed was a sea breeze, which we found did not extend to a height of more than 1000 or 1500 ft. There is no regular sea and land breeze on the West Coast of Scotland in fair weather as there is in some places on the coast of the Channel, but on sunny afternoons the wind sometimes rises from the West or North-west about 1 P.M., reaches a force of 4 or 5 about 4 P.M., and then sinks again to a calm at 8 or 9 P.M. We always found on these occasions that the wind was strongest at the surface, and failed completely above, and also that it was strongest at the mouth of the bay. It was seldom on such afternoons that we could get a kite above 1500 ft., thus showing that it was quite calm at that height. I believe these winds to be true sea breezes, although perhaps I should not have recognised them as such had not my attention been called to the subject by Mr. Marriott.

The height of the clouds forms an interesting subject of study in connection with kite-flying. The lower surface of a layer of clouds is by no means at a fixed and definite height, neither is the lower limit sharply defined. The kite, as it rises gradually, becomes hazy, but does not disappear until perhaps some 200 ft. higher. Then probably it reappears, possibly two or three times, before it is finally lost to sight. It does not by any means follow that when a kite is hidden it is necessarily in the clouds. On several occasions when it was raining at the surface the hygrometer trace showed that the upper kite had been in very dry air above the clouds. On another occasion, with a rising wind and light rain, which in an hour or two became very heavy, the cloud layer from which the rain was apparently falling was not reached at an elevation of 8800 ft.

But the most noticeable point was the very different level at which the clouds lay on the hills and mountains, and at which they were

encountered by the kite. The air on the West Coast of Scotland is remarkably clear, and it is seldom that mountains 30 to 40 miles distant cannot be seen. Since within that distance of Crinan there are hills of all heights up to 4000 ft., it was always possible to discover the cloud level on the mountains, and it was invariably found that this was less than that shown by the kites, sometimes less than half. In the Sound of Jura, a channel some 5 miles wide, clouds often lay on the hills on both sides, at an elevation of 500 ft., or even less, but in the middle of the Sound the kite would not reach the clouds under 1500 ft.

Wind Direction.

Kite-flying from a vessel has many advantages, but it has one disadvantage, and that is the difficulty of finding the true direction of the wind. It seems hardly necessary to point out that the line of smoke from the funnel of a moving vessel does not, as a rule, agree with the true direction, which can only be determined by the waves or ripple on the water. The direction of motion of the clouds cannot be determined at all, unless the vessel be stopped or her course altered for the purpose, and the same statement applies to the wind which is supporting a kite. Assuming that the velocity of the clouds is considerable compared with that of the vessel, or in any case when the direction is nearly coincident with that of the vessel, a very fair guess at their true direction may be made. At Crinan it was not always advisable to stop the vessel or alter her course, although this was sometimes done, for the purpose of noting down the true direction of the upper current. In general it was guessed at, and probably correctly so, within one point.

This is not the place to enter into the theory of this subject, which indeed will be found in any elementary text-book on dynamics, but it may be pointed out that a person having the use of a vessel of moderate speed, which can be moved in any direction, and also possessing a watch and a sextant, is able to obtain the height and velocity of any cloud that retains its shape and identity for a few minutes, and I think he can do so with greater accuracy by this than by any other method.

Temperature over the Sea.

A great uniformity of temperature was found to prevail from hour to hour over the sea, and this applies almost as much to the Sounds of Jura and Scarba as to the open water to the south of Mull. I believe the daily range of temperature over the ocean to be less than half a degree, for we found, with Westerly winds, that the temperature was just as likely to have decreased as to have increased between noon and 7 or 8 P.M. Of course changes of temperature occur, but they do not seem to have any daily period. We had intended trying a few ascents in the early morning, at 3 or 4 A.M., but in view of this remarkable uniformity it did not seem worth while, and for the same reason no attempt was ever made to keep a kite up for any length of time, since, if there be no daily variation at the surface, we may be certain there is none above.

Change of Wind Velocity with Elevation.

There is certainly far less change of wind velocity and wind direction with elevation over the sea than over the land. On several occasions we found a very strong wind of perhaps 30 to 40 miles per hour blowing at a height of 1000 ft. when it was almost calm at the surface. On all these occasions the wind was between South-east and South-west. Twice a North-west wind, force 6, was found to decrease above, and once a North-east wind, force 7, failed entirely at 3000 ft. These instances however, are not sufficient to allow of the laying down of any rule. Speaking generally, the wind increased slightly with increasing elevation, excepting in calm settled weather.

No sign of any electrical manifestation was ever observed, but this was doubtless due to the fact that the metal pulley over which the wire passed when first reaching the winding-gear was carefully connected with a "good earth," *i.e.* the rudder of the vessel when on the vessel, and moist ground when on the island.

I cannot close this Address without expressing the hope that a permanent kite station may be established somewhere in the British Isles, and also that unmanned balloons may be sent up on the days specified by the International Aeronautical Commission. The information so obtained would be most valuable, and it is, to say the least, unfortunate that the country where it is most important to obtain this, owing to its proximity to the usual storm tracks, should be almost the last to employ the means now available for the purpose.

A Mississippi Tornado.—Mr. S. C. Emery, in the U.S. *Monthly Weather Review* for May 1902, gives the following graphic account of a tornado :—

During the afternoon of March 28, 1902, a tornado of considerable violence passed through the north-east portion of Mississippi and North-west Alabama. Its course lay in a direct line from south-west to north-east, through the northern portion of Calhoun County, Miss., where it originated, diagonally across the counties of Pontotoc, Lee, and Itawamba, Miss., and Franklin County, Ala.

The total distance over which the storm travelled was about 118 miles, and its rate of progress averaged 33 miles an hour, the progressive motion being much greater toward the end than at the beginning. The width of the storm's track ranged from 300 to 400 yards. The cloud was generally reported as funnel-shaped, and of a greenish yellow colour. Hail fell at various places along the storm's track, and in several instances severe hail-storms occurred a few miles to the north of the main storm. The hailstones were of unusual size, and caused considerable damage in the way of killing sheep and young lambs, breaking windows, etc. Though a large number of dwellings were destroyed, only two people are reported killed.

The tornado formed about 1.30 p.m. at a point 12 miles east of the village of Banner, Calhoun County, Miss. From there it moved north-east into Pontotoc County, passing about 1½ mile south of Randolph, a small village in the south-west corner of that county, reaching that place about 2 p.m. The cloud is described by an eye-witness at Randolph as being funnel-shaped and very black, and accompanied by remarkably severe thunder and lightning and

heavy rain mixed with hail, some of the hail being "as large as an inkstand." South of the storm the wind came from the South-east, and on the north side from North-east. Everything within the path of the storm was destroyed, and quite a number of people injured. One child was taken into the air and deposited in a tree top, where it was afterwards found with all the clothing stripped from its body except its shoes.

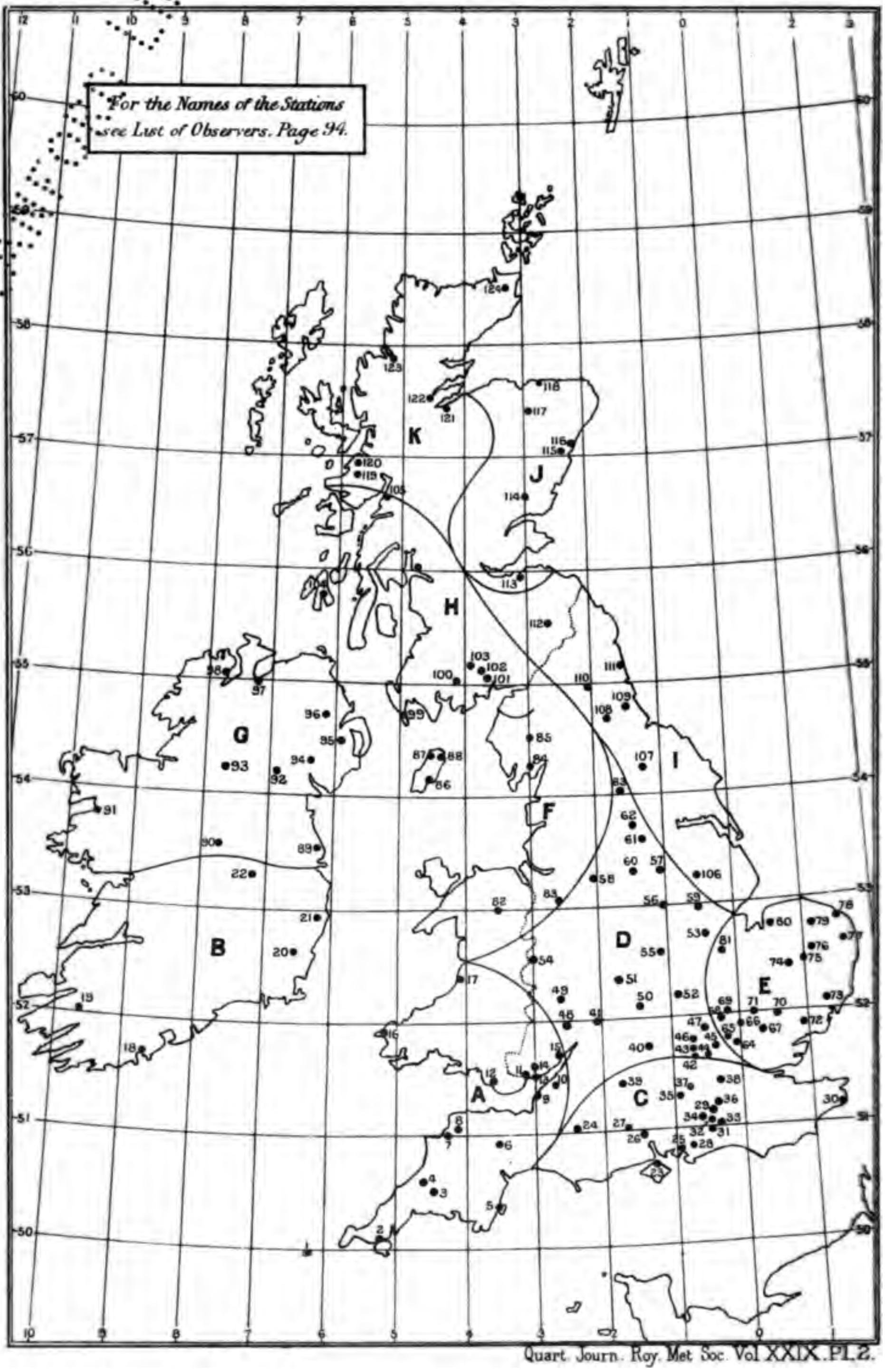
From Randolph the storm continued its north-east course to the village of Algoma, which was almost entirely destroyed, then on past Plymouth, which it skirted to the south, reaching Tupelo, Miss., at 2.40 p.m. The damage at Tupelo was considerable, 75 negro cabins being completely destroyed and many substantial buildings wrecked. From Tupelo the storm continued through Itawamba County, Miss., and crossed the Alabama line at the south-west corner of Franklin County. The first town in Alabama lying within the storm track was Isbell, which it reached about 3.45 p.m. Two churches were blown down, several dwellings more or less wrecked, and a large number of negro cabins destroyed. A cedar tree about 12 inches in diameter, which stood a few feet from a warehouse, was twisted off about 5 feet from the ground, and hurled through the building to the opposite side of the street, while the building itself was practically uninjured. After leaving Isbell it appears to have either lost its tornadic character, or, as is more probable, passed some distance above the surface. That the storm continued its north-east course is shown by the severe wind and hail-storms that occurred at points in a direct line with the course over which it had hitherto moved, the most notable being at Newburg, Mount Hope, and Moulton.

The weather map of March 28 presented an oval-shaped low, which extended from Texas to the central Mississippi Valley, with comparative highs over the north-west and south-east. The heavy and almost unprecedented downpours of rain that had prevailed for forty-eight hours over the greater portion of Tennessee, Alabama, and Mississippi were still in progress, and as a result many of the rivers were in a state of flood and a large section of country was covered more or less with water. Thunderstorms were generally reported in Texas, Louisiana, Arkansas, Tennessee, Missouri, and Illinois. The temperature over the south-east quadrant of the low averaged about 70°, while in the far north-west it was below freezing.

At Memphis on the day in question rains continued all day, with frequent heavy downpours. Dense fog formed in the west at intervals during the afternoon, and as it passed through the Arkansas forest the tree tops only could be seen, the trunks being hidden by the white cloud-bank. Two or three of these cloud-banks, which seemed to roll onward, passed over the station, indicating the presence of cold currents of air coming from above.

Hurricane and Great Wave in the Pacific.—On January 13, 1903, a terrible hurricane broke over the Society Islands and the Tecunotu group, and was accompanied by an immense wave which entirely devastated the islands and destroyed great numbers of people. The islands rise scarcely 20 feet above sea-level, and it is stated that the wall of water which swept their surface reached a height of 40 feet. Those of the inhabitants who escaped with their lives did so by climbing to the tops of the highest trees, but many of these were overturned by the water.

MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1902.



REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1902.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

(Plate II.)

[Read February 18, 1903.]

The following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Marazion in District A; Cork in District B; Blandford and East Molesey in District C; Watford (Oxhey Lane) in District D; Alderley Edge in District F; Carsethorn and Helensburgh in District H; and Chirnside in District I. On the other hand, new stations have been started, or old ones revived, at Tresco and Brixham in District A; Cranleigh in District C; Harefield, St. Albans (Kitchener's Meads), Ullenhall and Altofts in District D; Betley in District F; Monaghan and Enniskillen in District G; and Durris and Cullen in District J. The total number of observing stations is now 124.

The averages with which the mean dates of the different plants are compared in Table IV. have been obtained from the actual observations made during the 12 years 1891-1902 in all those districts where sufficient observations were available. Those for the remaining districts are as near approximations to the true averages as the limited number of records will allow.

TABLE I.—Mean Results, with their Variations from the 12 Years' Average (1891-1902), for the Thirteen Plants in those Districts where there have been sufficient Observations to warrant Comparisons being made.

Years.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+10	144	+ 9	150	+11	147	+11	150	+ 7
1892	139	+ 5	138	+ 3	144	+ 5	143	+ 7	147	+ 4
1893	118	−16	122	−13	125	−14	123	−13	128	−15
1894	126	− 8	130	− 5	135	− 4	127	− 9	137	− 6
1895	139	+ 5	138	+ 3	141	+ 2	138	+ 2	144	+ 1
1896	125	− 9	128	− 7	132	− 7	130	− 6	134	− 9
1897	130	− 4	132	− 3	136	− 3	132	− 4	142	− 1
1898	133	− 1	135	0	138	− 1	136	0	141	− 2
1899	136	+ 2	136	+ 1	141	+ 2	138	+ 2	145	+ 2
1900	142	+ 8	141	+ 6	144	+ 5	143	+ 7	152	+ 9
1901	138	+ 4	139	+ 4	141	+ 2	139	+ 3	144	+ 1
1902	139	+ 5	140	+ 5	145	+ 6	142	+ 6	152	+ 9
Mean	134	...	135	...	139	...	136	...	143	...

Explanation of the Dates in the Tables.

1– 31 are in	January.	182–212 are in	July.
32– 59 ,,	February.	213–243 ,,	August.
60– 90 ,,	March.	244–273 ,,	September.
91–120 ,,	April.	274–304 ,,	October.
121–151 ,,	May.	305–334 ,,	November.
152–181 ,,	June.	335–365 ,,	December.

The Winter of 1901–1902.

December was cold and February very cold in all parts of the country, the departures from the average in mean temperature in the latter month ranging from $-2°·5$ in the north of Scotland, to $-4°·7$ in the midland counties of England. In January, on the other hand, the weather continued unusually mild. Taking the winter as a whole, the temperature was below average. December proved wet, but during the other two months of the season, the fall of rain was deficient. Except in the south, east, and north-west of England, there was less than a seasonable record of sunshine.

Owing to the poor yield of hay and turnips in the previous year, the supply of winter keep for the cattle and sheep was unusually limited, so that the mild weather in January was welcomed by the farmers, as it enabled the pastures to remain green until severe weather set in in February. The cold period in February was also welcomed, as it came just in time to give a wholesome check to the young corn, which then threatened to become what is termed "winter proud." The preparation of the ground for spring corn was somewhat delayed by the wet weather in December, but throughout the greater part of January the land worked so well that at the end of the month all seasonable tillage operations were as forward as could be wished. The February frost, which affected the whole of the British Isles, in most districts lasted about three weeks. It was noteworthy as being the most prolonged frost experienced in February, with the exception of that of 1895, for half a century. Fortunately the cold was only for a short time severe, and the soil and sub-soil unusually dry, so that although in most parts of the country there was no snow covering, but little injury was done. In fact, at the end of the season the young corn has seldom so early in the year presented a more vigorous and healthy appearance.

The absence of any keen frosts worth mentioning in December and January favoured the rather scanty crops of green vegetables in the kitchen gardens. These crops, however, as well as some half-hardy shrubs and other plants, suffered a good deal in exposed positions during the severe weather in February. Otherwise the change was welcomed as giving a much needed check to the fruit buds and vegetation generally.

The female flowers on the hazel made their appearance rather in advance of their usual time in the warmer districts, but were somewhat late in the north of England, Ireland, and Scotland.

The song-thrush was first heard after the beginning of the year, 7 days earlier than its average date.

The honey-bee was first observed to visit flowers 3 days before its usual time.

The Spring.

In March the mean temperature was everywhere above average, but during the greater part of April and May the weather continued cold, and more particularly was this the case in May, which was in all parts of the country a very cold spring month. The records of rainfall and sunshine proved variable, but were in most districts in excess of their respective means for the quarter.

This proved a most satisfactory season for preparing the land for sowing all kinds of spring seeds. Indeed, throughout nearly the whole of the quarter, notwithstanding the wet weather in May, the ground continued in admirable condition for all tillage operations. So that beans and peas, wheat and barley, and later on, mangolds, turnips, and swedes, were all planted under exceptionally favourable conditions. Notwithstanding the small rainfall, the grass during March and April made good growth for the time of year, but everything remained nearly at a standstill during the long spell of cold weather in the middle of May. With a change to warmer conditions afterwards, the corn and other crops began to grow again, and were, as a rule, at the end of the spring in all respects as satisfactory as could be wished.

Seed sowing in the gardens was also carried out under equally propitious circumstances. The fruit trees flowered abundantly, and the prospects of a good fruit season were maintained until about the end of April, when strong North-easterly winds and night frosts destroyed much of the blossom. Where the frosts were most keenly felt, a large number of the half-grown gooseberries fell from the bushes. Early potatoes were also in many low-lying localities cut to the ground. In the case of the orchard trees it is contended, and I think rightly, by one of our most experienced observers in such matters, that it was rather the want of sufficient moisture in the subsoil, than to any adverse weather influences at the time of flowering, that caused the crops to be as a rule so small, and the fruit generally so undersized.

Owing to the cold weather in February, the flowering of the colts-foot was in all the earlier districts much behind its usual time. The mean date for the first flowering of the wood anemone was about average, that of the blackthorn and garlic hedge mustard 2 days late, while the horse chestnut and hawthorn, doubtless owing to the cold period in May, were respectively 4 and 7 days late.

Taking the spring migrants on the list, both the swallow and cuckoo arrived 2 days in advance of their average dates, and the nightingale 4 days early. On the other hand, the flycatcher made its appearance 9 days later than usual.

The wasp was first observed 2 days behind its usual time, while the small white butterfly was 9 days late, and the orange-tip butterfly 8 days late.

The Summer.

This was a cold, dry, and sunless season. In each month the temperature remained for the most part low, and especially was this the case in August, when there occurred in most districts very few days which were in any way unseasonably warm. Taking the season as a whole, the rainfall, except in the south and east of England, was below average; and in all parts of the British Isles there was a deficient record of sunshine.

The good growth made by all farm produce at the end of May was continued during the first week in June. Then came a cold, dull, and wet period lasting about a fortnight, during which little further progress took place. After that time the weather remained warm, dry, and sunny, until after the middle of July. This welcome change, coming as

it did when there was abundant moisture in the soil, accelerated the growth of the grass, so that in all the earlier districts a heavy crop of hay was gathered in at little expense and in excellent condition. The corn crops improved and became firmer in the straw—which had threatened to be wanting in substance, owing to the previous wet, cold, and sunless weather. The roots were also benefited. The low

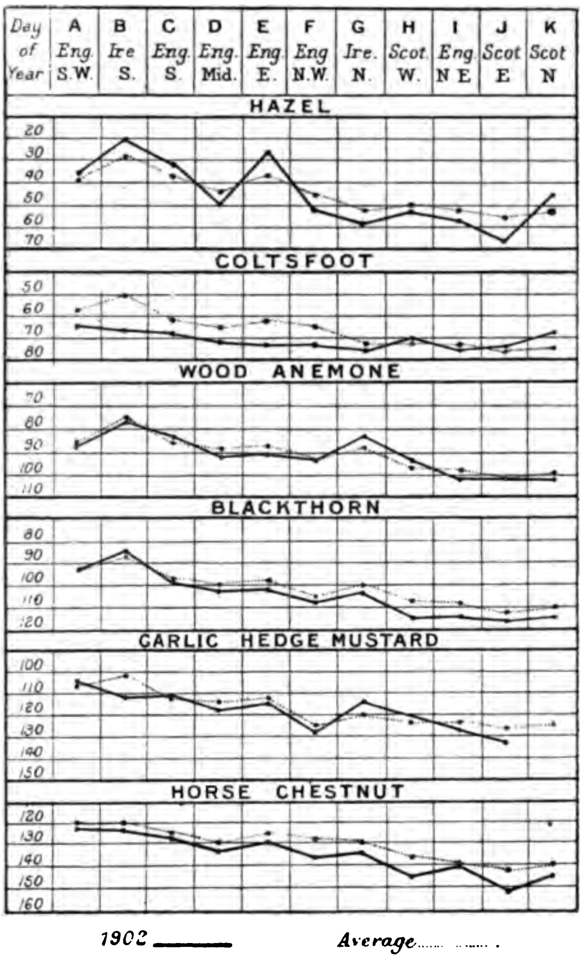


FIG. 1.

temperatures and scanty sunshine in August caused the cereals to ripen very gradually. In the same month the corn harvest began in the southern half of England under very trying conditions, owing to the frequent and often heavy falls of rain. For weeks after being cut, it stood in the sheaves exposed to the rain, so that the grain became stained, and in many cases sprouted. Fortunately the sprouting was less general than otherwise would have been the case, owing to the continued low temperature. In the colder districts of the British Isles

a great deal of hay was spoilt through the same adverse weather influences. Although unfavourable both to the corn harvest in the south, and to the hay harvest in the north, the wet weather suited the pastures, in which there was an excellent crop of herbage throughout the whole season. The potato disease made its appearance during August, and in many parts of England spread rapidly.

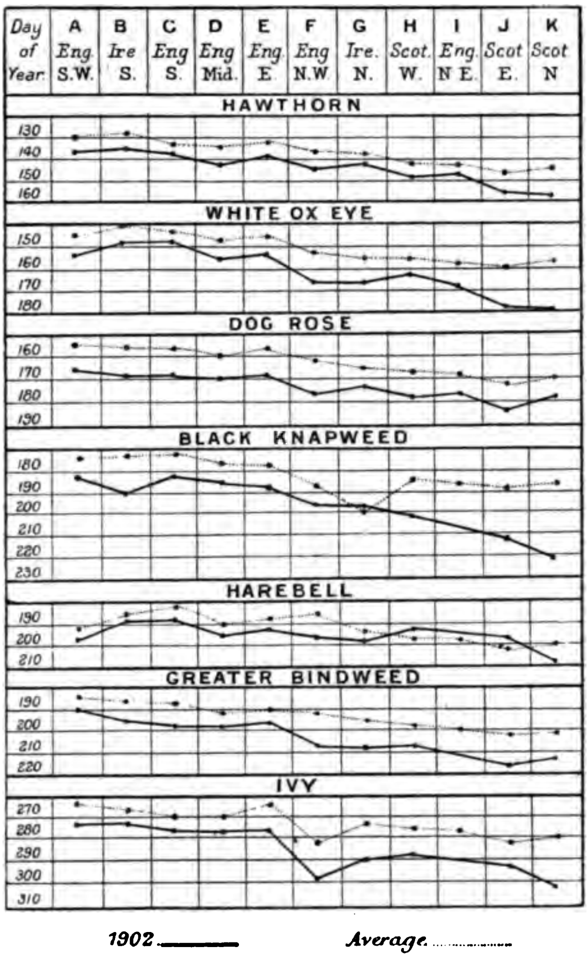


FIG. 2.

After the various plants in the flower and kitchen garden had recovered from the check they had received in the middle of June, they made good progress. Weeds too, encouraged by the frequent rains, grew apace, and were with difficulty kept in check. The summer fruits, as a rule, yielded poorly, and were deficient in flavour. Contrary to what has occurred in recent years, the lawns remained green throughout the whole summer.

This was one of the worst seasons for many years for bringing to maturity and harvesting most kinds of agricultural and garden seeds.

The hawthorn and other summer-flowering shrubs blossomed abundantly. There were, as a rule, very few wasps anywhere, while the season appears to have been equally unfavourable for bees, which made an unusually small quantity of honey. Butterflies were also very scarce.

The summer flowering plants on the list, with the exception of the shallow rooted harebell, were all exceptionally late in coming into blossom. The white ox-eye was 11 days late, the dog rose 10 days late, the black knapweed 14 days late, the harebell 4 days late, and the greater bindweed 10 days late.

The meadow-brown butterfly first made its appearance 7 days later than usual.

The Autumn.

This was the only one of the four seasons when the mean temperature was above average. Indeed, each of the three months composing it were, in nearly all parts of the country, more or less unseasonably warm. The fall of rain was very deficient, particularly in the east, north-west, and north-east of England, and the east and north of Scotland. In the districts in question, the departures from the average ranged between −3·4 ins. to −4·1 ins. Throughout the greater part of the British Isles there was, as in the previous quarter, a scanty record of sunshine.

The weather during September was a great improvement on that of August for all kinds of harvest work, and enabled the farmers to gather in their heavy corn crops with little further hindrance. In the earlier districts the harvest was completed by the middle of September, but unfortunately only here and there was the grain unstained by wet, and in many places much of it had sprouted. Its deteriorated quality is shown by the average price of English wheat early in October, which had in the previous five weeks fallen as much as 5s. 9d. a quarter, whereas the price of foreign wheat in the same period had slightly advanced. In all parts of the kingdom the yield of grain and straw was abundant; but almost everywhere, owing to the unfavourable weather, the harvest was one of the latest and most protracted for many years. The delay was not only caused by the frequent rains, but also by the heavy storms of rain and hail which in so many places had beaten down the corn. In some of the elevated districts of Scotland the corn crops never came to maturity, and had to be cut in a green state. Throughout the season there was, as in the summer, an abundant supply of keep in the pastures. The weather also favoured the root crops, all of which made good growth. As is usual after a cool showery summer, there was everywhere a great plague of all kinds of weeds. The potato disease appears to have been most felt in the south of England, less so in the north of England and in Scotland, and what is very unusual under similar conditions, least of all in Ireland. The preparation of the land for the sowing of autumn wheat, etc., was carried out under favourable conditions, and by the end of October about half the wheat crop had been already planted.

Seldom have our British gardens been as gay with flowers as they were this autumn, and still less often has the flowering period lasted

until so late in the season. Even in the midlands, dahlias, roses, etc., were gathered in good condition as late as the middle of November. The winter supply of vegetables also made excellent growth; indeed, before the winter set in the plants were in many places larger than could be wished.

There was this year an unusually scanty crop of acorns, but haws, hazel nuts, blackberries, and most other wild fruits were, as a rule, abundant.

The last plant on the list, the ivy, was 11 days later than usual in coming into flower.

The swallow, as a rule, left this country 2 days earlier than its average date.

According to the *Preliminary Statement* for Great Britain, issued by the Board of Agriculture, the yield of wheat exceeded the average for the previous 10 years by 2·94 bushels per acre, barley by 2·01 bushels, oats by 4·39 bushels, beans by 5·22 bushels, peas by 2·88 bushels, turnips by 2·23 tons per acre, mangolds by 3·65 tons, hay (permanent pasture) by 5·65 cwt. per acre, and clover, etc., by 5·27 cwt. per acre. In fact, with the exception of potatoes, which were deficient by 0·35 tons per acre, all the ordinary farm crops were more or less in excess of the average. The yield of oats, turnips, and mangolds was the heaviest per acre since "Produce Returns" were first made in 1884. In Ireland the yield of wheat, barley, oats, beans, peas and potatoes was much in excess of that in Great Britain. On the other hand, there were much heavier crops of mangolds and hay in Great Britain than in Ireland. The yield of turnips and swedes was in both cases equally good.

Taking the British Isles as a whole, the corn harvest began 10 days later than the mean date for the previous 13 years, and later than in any year since 1892.

The yield of fruit was exceptionally poor. The crop of apples, pears, and plums was in all parts of the kingdom under average, and with the exception of Ireland, raspberries, currants, and gooseberries were also deficient. Indeed, the only crop which was generally over average was that of strawberries.

The Year.

In all parts of the British Isles the phenological year ending November 1902 was for the most part cold and sunless. Rain fell at unusually frequent intervals, so that although the total quantity proved deficient, there at no time occurred any period of drought. Wild plants were everywhere behind their mean dates in coming into flower, but the departures from the average were, as a rule, slight, until about the middle of May. After that time until the end of the flowering season the dates of blossoming were later than in any other year since the present series of records were instituted in 1891. The swallow, cuckoo, and nightingale were a few days earlier than usual in making their appearance in this country. The most remarkable feature as regards the weather, and its effect on vegetation, was the way in which it favoured the growth of all the farm crops, except potatoes and hops. For it is seldom in the same year that the yield of wheat, barley, oats, beans, peas, turnips, mangolds, and grass are alike abundant even in a single district, much less, as was the case in 1902, in all parts of the kingdom. On the other hand, all

TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
A		Ft.	
1. Tresco	Isles of Scilly	5	J. Jenkin.
2. Mawnan	Cornwall	200	Miss R. Barclay.
3. Liskeard	Cornwall	400	S. W. Jenkin, C.E.
4. Altarnon	Cornwall	600	C. U. Tripp, M.A., F.R.Met.Soc.
5. Brixham	Devon	40	F. W. Millett.
6. Tiverton	Devon	270	Miss M. E. Gill.
7. Westward Ho	Devon	130	Miss Patterson.
8. Barnstaple	Devon	90	T. Wainwright.
9. Sidcot	Somerset	200	W. F. Miller.
10. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11. Penarth	Glamorgan	120	G. A. Birkenhead.
12. Bridgend	Glamorgan	90	H. J. Randall, Junr.
13. Castleton	Monmouth	80	F. G. Evans, F.R.Met.Soc.
14. Little Mill	Monmouth	300	W. J. Grant, F.R.H.S.
15. St. Arvans	Monmouth	360	Miss M. Peake.
16. St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
17. Aberystwith	Cardigan	30	J. H. Salter, D.Sc.
B			
18. Skibbereen	Cork	30	J. J. Wolfe.
19. Killarney	Kerry	100	Ven. Archdeacon Wynne, D.D.
20. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc., F.L.S.
21. Ovoca	Wicklow	110	Miss W. F. Wynne.
22. Geashill	King's County	280	Rev. Canon Russell.
C			
23. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
24. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
25. Havant	Hants	30	H. Beeston.
26. Botley	Hants	30	Lady Jenkyns.
27. Fordingbridge	Hants	90	S. Bramley.
28. Birdham	Sussex	10	A. J. Nixon.
29. Muntham	Sussex	250	P. S. Godman, F.Z.S.
30. Dover	Kent	150	F. D. Campbell.
31. Chiddingfold	Surrey	230	Vice-Admiral Maclear, F.R.Met.Soc.
32. Cranleigh	Surrey	80	Miss H. E. Ravenscroft.
33. Winterfold	Surrey	580	R. Turvey.
34. Coneyhurst	Surrey	600	J. Russell.
35. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
35. Churt	Surrey	300	C. Criddle.
36. Oxshott	Surrey	210	W. H. Dines, F.R.Met.Soc.
37. Bagshot	Surrey	230	W. Burgess.
38. Weston Green	Surrey	30	H. T. Potter.
39. Marlborough	Wilts	480	E. Meyrick.
D			
40. Oxford	Oxford	200	F. A. Bellamy.
41. Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
42. Harefield	Middlesex	340	G. E. Eland.
43. Chesham	Bucks	300	Miss G. Keating.
44. Watford (The Platts)	Herts	240	Mrs. G. E. Bishop.
44. Watford (Weetwood)	Herts	270	Mrs. J. Hopkinson.
45. St. Albans (Kitchener's Meads)	Herts	270	A. E. Gibbs, F.L.S.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
45. St. Albans (Worley Road)	Herts	300	H. Lewis.
46. Berkhamsted	Herts	400	Mrs. E. Mawley.
47. Harpenden	Herts	370	J. J. Willis.
48. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
49. Leominster	Hereford	220	J. H. Arkwright.
50. Farnborough	Warwick	520	Miss D. J. G. Prater.
51. Ullenhall	Warwick	350	R. Mansell.
52. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
53. Thornhaugh	Northampton	90	Rev. H. H. Slater.
54. Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
55. Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
56. Beeston	Notts	210	G. Fellows.
57. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
58. Macclesfield	Cheshire	500	J. Dale.
59. Belton	Lincoln	200	Miss F. H. Woolward.
60. Sheffield	Yorks (W.R.)	450	Miss E. F. Smith.
61. Altofts	Yorks (W.R.)	120	H. G. Townsend.
62. Horbury	Yorks (W.R.)	210	W. Rushforth.
63. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
64. Broxbourne	Herts	120	Rev. H. P. Waller.
65. Hatfield	Herts	300	T. Brown.
66. Hertford	Herts	140	W. Graveson.
67. Sawbridgeworth	Herts	350	H. S. Rivers.
68. Hitchin	Herts	220	A. W. Dawson, M.A.
69. Odsey (Ashwell)	Cambridge	260	H. G. Fordham.
70. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
71. Wenden	Essex	250	Miss L. Cornwall.
72. Lexden	Essex	90	S. F. Hurnard.
73. Sproughton	Suffolk	30	Rev. A. Foster-Melliar.
74. Market Weston	Suffolk	150	Rev. E. T. Daubeney.
75. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
76. Tacolneston	Norfolk	190	Miss E. J. Barrow.
77. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
78. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
79. Hevingham	Norfolk	...	Major Marsham.
80. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
81. Peterborough	Northampton	30	J. W. Bodger.
F			
82. Palé	Merioneth	600	T. Ruddy.
83. Betley	Cheshire	370	Miss M. L. Hodgson.
84. Newby Bridge	Lancashire	210	Miss L. Burton.
85. Ambleside	Westmoreland	260	Dr. G. A. Johnston and Miss Armitt.
86. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
87. Orry's Dale	Isle of Man	70	Miss C. M. Crellin.
88. Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G			
89. Ardgillan	Dublin	210	J. Woodward.
90. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
91. Westport	Mayo	10	J. M. McBride.
92. Monaghan	Monaghan	300	Miss De Vismes Kane.
93. Enniskillen	Fermanagh	160	J. T. Abraham, F.R.Met.Soc.
94. Loughbrickland	Down	350	Rev. Canon Lett.
95. Saintfield	Down	310	Rev. C. H. Waddell, M.A.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station	County.	Height above Sea-level.	Observer.
		Ft.	
96. Antrim	Antrim	70	Rev. W. S. Smith.
97. Altnafoyle	Londonderry	450	T. Gibson.
98. Ramelton	Donegal	200	Miss K. Swiney.
H			
99. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson.
100. New Galloway	Kirkcudbright	450	T. R. Bruce.
101. Dumfries	Dumfries	70	Miss Cresswell.
102. Jardington	Dumfries	100	J. Rutherford.
103. Moniaive	Dumfries	350	J. Corrie.
104. Port Ellen	Isle of Islay	10	T. F. Gilmour.
105. Duror	Argyll	20	R. Macgregor.
I			
106. Doddington	Lincoln	90	Rev. R. E. Cole.
107. Thirsk	Yorks (N.R.)	120	A. B. Hall.
108. Willington	Durham	280	Miss A. Clench.
109. Durham	Durham	350	Prof. R. A. Sampson and F. C. Carpenter.
110. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
111. Blyth	Northumberland	20	S. Dunnett.
112. Lilliesleaf	Roxburgh	530	Miss C. M. D. Sprot.
J			
113. Edinburgh	Edinburgh	..	W. Evans.
114. Kirriemuir	Forfar	250	T. M. Nicoll.
115. Durris	Kincardine	420	A. Macdonald, M.A.
116. Aberdeen	Aberdeen	40	P. Harper.
117. Newmill	Banff	350	J. Ingram.
118. Cullen	Banff	80	J. Fowlie.
K			
119. Invermoidart	Inverness	60	S. M. Macvicar.
120. Roshven	Inverness	40	H. Blackburn.
121. Beauly	Inverness	60	A. Birnie.
122. Dingwall	Ross	10	J. P. Smith, M.D.
123. Inverbroom	Ross	50	Lady Fowler.
124. Watten	Caithness	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations, Plate II.

the fruit crops were more or less deficient, with the exception of strawberries which yielded well, but were like most other fruits lacking in flavour.

Observers' Notes.

December 1901.—*Altarnon* (A)—25th. Woodpecker and Great Tit calling. *Bembridge* (C)—7th. Newly-planted trees are suffering from the want of rain. *Hodsock* (D)—12th. Shrubs much injured and broken by snowstorm and wind —not only evergreens, but also thorns and lilacs. *Brunstead* (E)—Great scarcity of holly-berries. *Jardington* (H)—Very few haws or holly-berries.

January 1902.—*Mawnan* (A)—2nd. Great Tit heard. *Bridgend* (A)—6th. Woodpecker first heard. *Aberystwith* (A)—12th. Great Tit heard. *Berk-*

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1902.

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
A													
Tresco . .	...	...	...	93	...	...	114	...	...	...	...	...	...
Mawnan . .	...	...	...	...	...	119	141	167	172	189	...	...	274
Liskeard . .	...	...	...	89	...	...	...	...	...	...	...	...	...
Altarnon . .	42	75	108	109	116	127	157	171	181	198	208	209	296
Brixham . .	38	64	...	80	...	120	130	...	168	179	...	195	268
Tiverton . .	59	...	88	88	90	127	130	...	161	...	...	...	276
Westward Ho .	54	55	104	99	*135*	126	143	162	166	*203*	...	*217*	298
Barnstaple . .	27	65	93	86	102	124	138	159	166	187	192	198	270
Sidcot . . .	18	63	74	105	111	115	130	134	152	...	...	...	...
Clifton . .	...	...	...	110	...	120	138	...	173	...	...	...	264
Bridgend . .	58	70	82	...	...	130	139	157	175	179	200	196	...
Castleton . .	39	61	74	85	109	110	133	147	160	179	...	191	273
Little Mill . .	16	59	74	81	102	113	132	137	162	163	...	172	258
St. Arvans . .	21	66	78	98	116	125	140	161	169	...	...	...	264
St. Davids . .	...	77	...	89	...	124	*110*	153	...	...	...	177	...
Aberystwith .	23	54	92	79	103	124	142	145	153	183	183	182	266
B													
Skibbereen . .	31	...	75	77	...	129	128	143	163	190	...	180	273
Killarney . .	17	...	86	88	111	111	117	144	168	196	189	208	251
Ferns . . .	*83*	89	87	79	...	*146*	144	150	171	181	...	196	303
Ovoca . . .	11	43	68	76	...	126	139	...	...	193	...	...	...
Geashill . .	...	...	76	98	...	121	148	159	174	...	...	...	263
C													
Bembridge . .	26	54	...	95	111	116	133	144	...	...	...	...	...
Buckhorn Weston	13	54	86	98	97	127	134	141	168	182	...	202	266
Havant . .	12	81	...	103	103	124	129	146	167	179	...	199	275
Botley . .	27	84	84	98	110	132	138	151	174	186	*213*	210	296
Fordingbridge .	9	...	85	85	...	137	141	167	178	...	...	...	...
Birdham . .	...	71	...	93	112	121	127	141	160	165	...	181	285
Muntham . .	27	68	75	96	106	125	129	149	157	178	...	187	280
Dover . . .	...	...	...	90	...	122	...	...	175	184	...	...	270
Chiddingfold .	27	61	77	95	113	124	137	148	171	180	193	199	268
Cranleigh . .	58	64	84	100	114	134	140	149	171	187	...	...	281
Winterfold . .	55	...	93	100	...	*150*	148	159	...	...	200	...	327
Coneyhurst . .	62	...	80	103	122	138	144	150	164	181	179	*161*	257
Churt Vicarage .	20	76	88	108	117	127	142	148	170	183	190	209	273
Churt . . .	6	82	90	110	113	130	133	134	*130*	187	189	199	249
Oxshott . .	61	67	85	96	117	...	...	...	...	...	...	...	...
Bagshot . .	55	74	94	108	...	124	144	132	167	188	...	206	280
Weston Green .	27	40	...	103	114	121	135	148	179	185	199	196	267
Marlborough .	10	62	72	109	104	129	144	153	172	...	175	190	263
D													
Oxford . .	22	...	...	...	...	124	137	143	171	180	...	...	263
Beckford . .	41	61	78	94	105	123	128	145	168	177	199	182	273
Harefield . .	60	68	109	108	...	123	131	157	...	...	*216*	205	...
Chesham . .	8	...	...	98	113	129	144	148	171	*218*	...	189	...
Watford (The Platts)	58	90	...	86	...	132	141	...	*154*	...	198	...	282
Watford (Weetwood)	38	...	91	101	106	120	143	153	173	192	188	...	277
St. Albans (Kitchener's Meads)	...	...	...	...	...	137	139	...	...	...	...	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1902—*continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
Berkhamsted	60	57	95	105	119	136	152	152	165	189	196	189	292
Harpenden	34	72	102	103	115	132	144	...	169	191	186	199	...
Ross	22	66	76	89	95	125	122	...	168	182	...	...	270
Leominster	...	...	83	81	...	143	144	...	...	...	...	179	...
Farnborough	61	60	90	103	126	141	137	146	166	...	205	204	295
Ullenhall	63	87	94	114	113	127	143	154	158	167	209	*224*	...
Northampton	59	69	75	107	114	130	141	...	174	180	192	201	263
Thornhaugh	58	...	...	...	...	..	...	...	...	...	...	...	...
Churchstoke	43	69	89	103	127	138	139	...	165	205	208	217	...
Thurcaston	61	63	91	111	120	137	145	159	171	168	199	199	...
Beeston	61	74	...	109	121	141	144	*173*	176	187	164	...	...
Hodsock	59	73	91	106	116	122	145	163	171	188	...	...	284
Macclesfield	57	83	102	107	...	151	153	165	172	189	191	193	271
Belton	54	77	95	93	127	122	144	...	...	...	...	...	...
Sheffield	65	78	83	...	...	135	148	166	*189*	192	193	215	...
Altofts	62	63	87	88	133	140	140	161	177	186	200	214	277
Horbury	62	68	100	121	124	...	139	...	...	...	...	...	...
Ripley	25	75	96	117	136	142	155	164	...	...	...	...	...
E													
Broxbourne	20	...	...	...	...	...	...	...	...	...	...	...	271
Hatfield	23	80	93	103	...	120	133	152	166	194	195	201	...
Hertford	12	65	75	82	110	129	122	149	173	187	198	198	271
Sawbridgeworth	...	72	...	97	...	140	149	...	...	...	...	...	...
Hitchin	25	68	...	...	...	...	...	...	...	...	...	...	277
Odsey (Ashwell)	10	...	...	102	...	...	...	...	172	...	...	...	280
Bocking	20	66	100	108	111	125	131	162	161	186	201	210	...
Wenden	...	...	...	96	...	137	131	...	...	...	...	...	...
Lexden	58	76	92	102	114	127	137	149	170	179	183	...	274
Sproughton	10	71	76	106	113	123	143	149	165	...	...	...	...
Market Weston	...	69	86	98	115	141	141	151	*153*	166	181	185	261
Carleton-Forehoe	10	76	...	111	116	132	146	152	173	189	202	189	269
Tacolneston	21	70	101	108	110	...	142	...	168	...	...	183	...
Brundall	40	...	86	112	122	125	145	153	172	...	...	...	291
Brunstead	16	68	99	109	115	139	147	156	170	205	183	206	280
Hevingham	...	...	87	...	...	...	148	...	...	...	...	...	...
Clenchwarton	...	70	...	90	...	131	140	...	172	210	...	...	264
Peterborough	65	86	90	93	114	125	125	146	168	...	...	...	292
F													
Palé	58	...	108	109	131	142	149	151	176	195	196	227	298
Betley	45	75	79	110	*92*	135	139	170	173	199	191	196	303
Newby Bridge	27	76	88	109	124	142	152	167	176	198	202	199	285
Ambleside	62	70	99	108	127	143	...	...	...	...	...	...	...
Cronkbourne	63	68	*126*	...	130	135	148	161	...	...	197	*242*	311
Orry's Dale	...	...	...	109	...	122	134	178	181	...	...	...	...
G													
Ardgillan	60	70	92	106	...	136	146	163	182	212	...	*232*	301
Edgeworthstown	...	...	93	99	...	144	144	...	...	...	...	...	...
Westport	48	...	68	94	...	121	132	...	166	...	...	...	267
Monaghan	55	65	68	96	...	132	143	...	171	189	...	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1902—*continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
Enniskillen	53	61	79	97	117	130	139	153	171	182	195	191	...
Loughbrickland	62	94	105	109	...	135	146	177	179	200	202	214	276
Saintfield	60	75	87	109	...	129	145	164	179	...	...	...	313
Antrim	69	...	...	106	108	...	143	172	...	201	...	222	293
Altnafoyle	55	78	...	114	...	146	142	...	171	208	...	...	...
Ramelton	66	...	73	...	...	133	145	169	173	...	...	...	...
H													
Kirkmaiden	...	51	...	115	...	147	150	...	181	...	...	199	...
New Galloway	19	...	105	...	...	*160*	161	167	178	...	196	...	...
Dumfries	...	...	99	112	*146*	146	151	153	171	...	182	...	...
Jardington	59	87	88	114	...	147	148	...	178	210	193	...	...
Moniaive	61	75	90	115	...	...	158	...	179	*221*	200	214	...
Port Ellen	60	...	95	...	...	141	142	...	...	...	...	...	...
Duror	63	66	79	112	...	...	132	166	173	191	189	...	288
I													
Doddington	64	90	97	112	120	132	145	159	175	...	...	...	...
Thirsk	22	70	92	106	120	125	138	169	174	...	...	...	...
Willington	70	63	...	...	...	145	...	...	...	...	...	...	...
Durham	68	68	92	119	...	146	154	178	186	...	...	...	...
Corbridge-on-Tyne	63	69	105	113	119	...	150	...	...	...	...	...	...
Blyth	54	67	...	107	...	143	146	...	172	...	...	...	...
Lilliesleaf	*110*	98	118	129	145	149	...	...	...	...	...	...	...
J													
Edinburgh	72	69	105	113	...	...	...	...	...	...	...	...	...
Kirriemuir	...	81	...	119	...	...	157	181	181	210	186	...	...
Durris	66	85	94	118	123	153	...	...	177	212	197	205	293
Aberdeen	...	69	*121*	...	...	...	...	202	...	...	211	...	...
Newmill	65	73	95	110	130	155	165	174	191	213	*224*	228	...
Cullen	..	75	110	...	149	148	146	159	...	...	185	...	...
K													
Invermoidart	20	...	105	...	...	...	156	175	176	...	...	...	...
Roshven	49	54	104	...	...	134	147	178	178	212	...	213	299
Beauly	55	76	100	121	...	158	164	180	180	212	199	...	304
Dingwall	61	68	98	111	...	142	159	173	177	...	209	...	...
Inverbroom	*6*	...	110	110	...	...	...	...	181	225	218	.	...
Watten	...	73	...	...	...	...	170	195	...	236	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

hamsted (D)—26th. No measurable quantity of rain-water has come through either of my percolation gauges for a fortnight. *Ripley* (D)—23rd. Great Tit heard.

FEBRUARY.—*Mawnan* (A)—10th. Lowest temperature for years. *Altarnon* (A)—14th. Starlings and thrushes found dead. *Aberystwith* (A)—25th. Frog spawn first seen. *Ovoca* (B)—28th. Frog spawn first seen. *Geashill* (B)—24th

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF 13 PLANTS IN 1902, AND THEIR VARIATIONS FROM THE 12 YEARS' AVERAGE, 1891-1902.

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1902.	Average for 12 Years.	Variation from Average.	1902.	Average for 12 Years.	Variation from Average.	1902.	Average for 12 Years.	Variation from Average.	1902.	Average for 12 Years.	Variation from Average.
Hazel	36	39	− 3	20	*29*	− 9	31	36	− 5	49	43	+ 6
Coltsfoot . . .	64	56	+ 8	66	*50*	+16	67	62	+ 5	71	65	+ 6
Wood Anemone . .	87	86	+ 1	78	*76*	+ 2	84	85	− 1	91	89	+ 2
Blackthorn . . .	92	92	Av.	84	*86*	− 2	99	98	+ 1	102	100	+ 2
Garlic Hedge-Mustard	106	107	− 1	111	*101*	+10	111	112	− 1	118	115	+ 3
Horse-Chestnut . .	121	120	+ 1	122	*120*	+ 2	127	126	+ 1	133	130	+ 3
Hawthorn . . .	136	130	+ 6	135	*128*	+ 7	137	132	+ 5	142	134	+ 8
White Ox Eye . .	154	145	+ 9	149	*140*	+ 9	147	142	+ 5	155	148	+ 7
Dog Rose . . .	166	155	+11	169	*156*	+13	169	157	+12	170	160	+10
Black Knapweed .	182	174	+ 8	190	*173*	+17	182	171	+11	185	177	+ 8
Harebell . . .	196	191	+ 5	189	*186*	+ 3	189	182	+ 7	195	190	+ 5
Greater Bindweed .	190	184	+ 6	195	*186*	+ 9	198	187	+11	199	191	+ 8
Ivy	273	264	+ 9	272	*267*	+ 5	276	270	+ 6	277	270	+ 7
Mean for the 13 Plants	139	134	+ 5	137	*131*	+ 6	140	135	+ 5	145	139	+ 6

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	25	37	−12	51	45	+ 6	59	52	+ 7	52	*50*	+ 2
Coltsfoot . . .	72	61	+11	72	65	+ 7	74	72	+ 2	70	*72*	− 2
Wood Anemone . .	90	88	+ 2	93	93	Av.	83	87	− 4	93	*96*	− 3
Blackthorn . . .	101	99	+ 2	109	106	+ 3	103	100	+ 3	114	*107*	+ 7
Garlic Hedge-Mustard	114	112	+ 2	128	125	+ 3	113	*119*	− 6	...	*122*	...
Horse-Chestnut . .	130	125	+ 5	136	129	+ 7	134	130	+ 4	145	*137*	+ 8
Hawthorn . . .	139	131	+ 8	144	137	+ 7	142	138	+ 4	149	*141*	+ 8
White Ox Eye . .	152	146	+ 6	165	152	+13	166	155	+11	162	*155*	+ 7
Dog Rose . . .	169	157	+12	176	161	+15	174	165	+ 9	177	*167*	+10
Black Knapweed .	189	178	+11	197	187	+10	199	200	− 1	201	*184*	+17
Harebell . . .	192	187	+ 5	196	185	+11	199	*194*	+ 5	192	*197*	− 5
Greater Bindweed .	196	190	+ 6	207	191	+16	209	*195*	+14	207	*198*	+ 9
Ivy	275	264	+11	299	282	+17	290	*274*	+16	288	*277*	+11
Mean for the 13 Plants	142	137	+ 5	152	143	+ 9	150	145	+ 5	154†	*148†*	+ 6†

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	57	*52*	+ 5	68	*55*	+13	46	*53*	− 7	45	45	Av.
Coltsfoot . . .	75	*74*	+ 1	75	*77*	− 2	68	*75*	− 7	70	66	+ 4
Wood Anemone . .	101	*98*	+ 3	101	*101*	Av.	103	*99*	+ 4	91	91	Av.
Blackthorn . . .	114	*109*	+ 5	115	*112*	+ 3	114	*110*	+ 4	104	102	+ 2
Garlic Hedge-Mustard	126	*124*	+ 2	134	*127*	+ 7	...	*125*	...	118	116	+ 2
Horse-Chestnut . .	140	*139*	+ 1	152	*142*	+10	145	*140*	+ 5	135	131	+ 4
Hawthorn . . .	147	*143*	+ 4	156	*146*	+10	159	*144*	+15	144	137	+ 7
White Ox Eye . .	169	*157*	+12	179	*160*	+19	180	*158*	+22	162	151	+11
Dog Rose . . .	177	*169*	+ 8	183	*172*	+11	178	*170*	+ 8	173	163	+10
Black Knapweed .	...	*186*	...	212	*189*	+23	221	*187*	+34	196	182	+14
Harebell . . .	...	*199*	...	195	*202*	− 7	209	*200*	+ 9	195	191	+ 4
Greater Bindweed .	...	*200*	...	217	*203*	+14	213	*201*	+12	203	193	+10
Ivy	...	*279*	...	293	*282*	+11	302	*280*	+22	284	273	+11
Mean for the 13 Plants	123*	*118**	+5*	160	*151*	+ 9	161†	*151†*	+10†	148	142	+ 6

* For 9 Plants. † For 12 Plants.

\+ indicates the number of days later than the average date.
− „ „ „ earlier „ „
Av. „ average date (1891-1902).
The dates in *italics* are approximate averages.

Bees out in great numbers over the snowdrops—quite a rare sight here. *Churt Vicarage* (C)—10th. Skylark first heard. *Berkhamsted* (D)—21st. No measurable quantity of rain-water has come through either of my percolation gauges since the month began. *Hodsock* (D)—8th. A heavy fall of snow. 22nd. When the snow melted the snowdrops were still in full flower, though still with short stalks. *Lexden* (E)—15th. Evergreens injured by frost. A large bush of *Olearia Haastii* killed. Last year's growth of Euonymus destroyed. *Sproughton* (E)—16th. Unprotected tender plants which were exposed to the sunshine suffered considerably from last night's frost. *Monaghan* (G)—8th. Snow from 10 to 15 ins. deep. Some Scotch firs had their tops broken off by the weight of the snow.

MARCH.—*Berkhamsted* (D)—23rd. Wryneck first heard. *Brunstead* (E)—18th. Frog spawn first seen. *Enniskillen* (G)—2nd. Frog spawn first seen. *Newmill* (J)—5th. Frog spawn first seen.

APRIL.—*Altarnon* (A)—23rd. Tree-pipit first heard. *Westward Ho* (A)—8th. Cuckoo first heard. During 30 years of observation have never before heard it previous to the 19th. *Bridgend* (A)—9th. House-martin first seen. *St. Arvans* (A)—13th. Willow-wren first heard. *Killarney* (B)—Sweet-peas, which were an inch high in the third week in March, hardly grew another inch in six weeks. *Coneyhurst* (C)—10th. Sand-martin first seen. *Churt Vicarage* (C)—4th. Wryneck first heard. *Bagshot* (C)—10th. The first plum blossom. 13th. The first pear blossom, and 22nd, the first apple blossom out. *Harefield* (D)—19th. House-martin first seen. *Watford* (D)—7th. Blackthorn blossom abundant. *St. Albans* (D)—13th. Wryneck first heard. 14th. Willow-wren first heard. 21st. House-martin first seen. *Beeston* (D)—13th. Willow-wren first heard. *Ripley* (D)—14th. Willow-warbler first heard. 16th. Sand-martin first seen. *Sproughton* (E)—19th. A small swarm of bees entered our church. *Tacolneston* (E)—21st. House-martin first seen. *Clenchwarton* (E)—Hawthorn blossom abundant. *Edgeworthstown* (G)—12th. Willow-wren first seen. *Antrim* (G)—21st. Willow-wren first heard. *Corbridge* (I)—16th. Sand-martin first seen. *Durris* (J)—17th. House-martin first seen.

MAY.—*Mawnan* (A)—14th. Apple blossom destroyed by frost and cold winds. *Altarnon* (A)—11th and 13th. Potatoes and also the young shoots on the gooseberries and currants injured by frost. 15th to 20th. Heavy squalls of wind, hail, and rain damaged the plum and early pear blossom, but the apple blossom, being only in bud, escaped. *Tiverton* (A)—The late spring frosts did much damage. *St. Arvans* (A)—11th. Potatoes blackened by frost. *Botley* (C)—The oak leaves were so damaged by frost that the caterpillars descended to the hazels, etc., below, and devoured instead the foliage of the underwood in the copses. *Chiddingfold* (C)—The sharp frosts in the middle of the month, and the heavy hail on the 18th, did great injury to fruit blossom. 26th. Leaf-roller caterpillars appearing in places on the oaks. *Churt Vicarage* (C)—8th. Much damage done by hailstorm to gooseberries and currants, and to the early blossoms on the fruit trees. 31st. May-fly first seen. *Bagshot* (C)—14th. Potatoes and French beans much injured by frost. *Oxford* (D)—27th. The large elms not yet in full leaf. *Beckford* (D)—14th. Much damage done by frost to potatoes and the blossoms of bush and other fruits. *St. Albans* (D)—7th. White-throat first heard. *Berkhamsted* (D)—6th. No measurable quantity of rain-water has come through either of my percolation gauges for a month. *Harpenden* (D)—Owing to the deficient rainfall fruit trees produced abundance of blossom, but the greater part, especially on the plums and cherries, fell off. The apples, even although they were formed, could not be brought to maturity by the trees, and they accordingly prematurely fell or developed into puny fruits. *Farnborough* (D)—For the first time in my 30 years of observation I have not seen an orange-tip butterfly during May. *Lexden* (E)—5th. House-martin first seen. *Market*

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1902.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Tresco	12	92	108	...	...	...	...	...	...	...	...
Mawnan	6	114	118	...	...	...	7	...	125	143	184
Liskeard	...	99	101	...	...	...	46	...	106	132	...
Altarnon	6	101	102	...	153	288	59	73	113	148	162
Brixham	2	103	107	...	...	294	...	...	78	...	190
Tiverton	...	100	96	...	...	...	90	...	...	...	...
Westward Ho	4	111	98	...	*209*	278	62	*148*	97	...	*205*
Sidcot	...	93	106	102	...	...	60	63	106	108	111
Clifton	...	...	101	109	...	...	60	...	*131*	...	...
Penarth	...	...	...	...	...	...	87	...	106	130	187
Bridgend	6	99	...	...	...	...	54	*143*	...	...	...
Castleton	5	94	103	...	149	293	5	103	114	114	144
Little Mill	19	95	103	114	126	284	37	65	92	103	128
St. Arvans	11	94	106	...	142	280	59	116	115	126	181
St. Davids	28	103	104	...	...	288	71	...	112	128	...
Aberystwith	3	99	113	...	...	268	38	107	80	144	155
B											
Skibbereen	3	98	102	...	...	290	55	125	101	117	178
Killarney	6	107	...	...	...	...	63	119	118	143	...
Ferns	2	*130*	115	...	...	291	74	116	102	118	140
Ovoca	9	99	120	...	...	287	64	119	105	115	115
Geashill	...	98	114	...	...	280	55	...	109	119	181
C											
Bembridge	1	94	102	102	...	315	60	...	...	153	...
Buckhorn Weston	6	101	104	114	144	286	57	75	103	114	178
Havant	1	97	102	103	...	328	11	114	108	130	176
Botley	3	95	106	104	137	296	60	...	89	144	184
Fordingbridge	3	95	104	109	*165*	...	60	*146*	...	144	...
Birdham	2	102	102	106	148	291	1	62	110	145	182
Muntham	4	102	103	103	...	298	...	...	...	...	...
Dover	...	122	...	...	...	289	...	...	...	...	...
Chiddingfold	2	98	103	103	143	295	53	117	...	152	172
Cranleigh	1	102	100	101	148	289	64	...	90	*171*	...
Winterfold	54	109	100	104	...	300	...	80	...	...	...
Coneyhurst	...	104	99	99	130	276	72	65	...	...	...
Churt Vicarage	7	103	102	106	149	283	57	103	108	144	181
Churt	8	103	102	104	137	295	25	64	120	132	140
Oxshott	8	111	103	109	...	...	...	...	...	...	...
Bagshot	3	105	99	109	129	274	57	107	108	128	...
Weston Green	2	107	103	106	...	288	60	79	103	...	...
Marlborough	58	94	110	114	143	...	...	...	108	144	178
D											
Beckford	57	107	106	108	147	285	47	69	116	144	171
Harefield	...	115	103	105	...	277	...	...	71	...	...
Chesham	...	102	105	104	...	285	6	138	...	134	...
Watford (The Platts)	1	113	104	106	...	*258*	...	115	86	...	...
Watford (Weetwood)	...	109	106	110	...	292	61	109	109	146	...
St. Albans (Worley Road)	3	100	104	104	...	...	...	...	...	...	...
Berkhamsted	1	104	103	106	137	286	23	66	76	152	211

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 902—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
Harpenden	18	99	107	107	...	...	...	...	...	...	...
Ross	...	107	107	111	147	278	66	...	109	...	...
Leominster	...	103	105	...	...	277	...	...	102	...	...
Farnborough	2	91	109	111	159	279	58	75	117	...	181
Ullenhall	...	113	110	*138*	...	...	...	...	...	...	170
Thornhaugh	11	...	...	...	...	...	16	...	...	...	...
Churchstoke	...	102	106	...	...	...	...	...	141	143	...
Thurcaston	...	106	112	...	...	...	...	104	*154*	153	...
Beeston	10	106	112	...	...	283	66	114	103	...	...
Hodsock	11	97	112	114	147	285	57	115	118	145	...
Macclesfield	47	...	110	...	...	273	...	...	...	...	...
Belton	3	104	106	108	137	...	58	100	145	148	...
Sheffield	18	*135*	...	...	...	...	64	*148*	143	...	...
Altofts	12	106	111	...	...	...	12	16	119	*164*	*243*
Ripley	25	99	107	...	...	265	23	119	118	...	...
E											
Broxbourne	4	98	106	110	146	303	35	107	114	...	...
Hatfield	8	103	105	103	146	...	...	...	...	...	...
Sawbridgeworth	3	97	106	110	...	296	56	105	118	...	185
Hitchin	1	...	...	102	...	...	18	...	...	...	...
Odsey (Ashwell)	13	95	111	109	147	302	...	...	...	...	...
Bocking	...	...	109	109	...	...	...	...	...	...	...
Wenden	52	105	103	105	...	...	...	...	...	103	...
Lexden	4	105	108	105	147	292	65	80	114	145	182
Sproughton	7	105	111	109	150	...	59	69	113	144	...
Market Weston	2	103	108	104	148	285	23	104	114	143	182
Carleton-Forehoe	6	106	111	...	146	296	57	98	142	144	...
Tacolneston	...	105	...	107	...	...	21	*144*	...	143	...
Brundall	...	...	106	106	...	...	...	...	...	...	...
Brunstead	3	110	107	...	147	282	58	106	114	148	185
Hevingham	44	104	111	112	...	...	...	...	...	...	...
Clenchwarton	10	107	100	...	...	284	56	74	116	147	...
Peterborough	5	116	114	106	...	...	50	110	109	150	...
F											
Palé	23	103	109	...	142	262	58	114	129	134	197
Betley	56	98	110	...	*166*	271	75	91	126	135	184
Newby Bridge	*82*	108	119	...	130	...	65	126	120	141	180
Ambleside	22	106	115	...	138	...	56	109	125	141	...
Cronkbourne	55	*136*	*133*	...	...	285	22	115	131	138	...
Orry's Dale	37	105	108	...	...	280	61	118	118	...	...
Sulby	12	109	108	...	...	293	91	134	101	...	150
G											
Ardgillan	17	110	119	...	...	258	...	106	119	...	127
Edgeworthstown	7	99	111	...	...	278	...	...	116	118	...
Westport	17	...	...	...	...	270	...	...	...	...	...
Monaghan	22	103	114	...	145	...	84	123	116	112	...
Enniskillen	3	105	108	...	...	...	61	...	...	...	...
Loughbrickland	52	108	115	...	..	263	56	...	107	139	...
Saintfield	20	112	112	...	149	...	74	117	111	149	...
Antrim	22	97	112	...	153	...	96	107	118	118	...

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 902—*continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
Altnafoyle	22	121	121	...	...	270	...	...	119	145	202
Ramelton	17	97	112	...	...	251	48	100	...	138	...
H											
Kirkmaiden	13	99	115	...	...	...	74	...	125	...	...
New Galloway	22	111	105	...	...	270	61	...	143	...	...
Dumfries	14	*138*	*131*	...	*165*	252	62	*165*	...	...	...
Jardington	54	107	118	...	...	274	...	116	115	...	179
Moniaive	55	104	114	...	128	283	...	...	106	...	...
Port Ellen	55	117	119	...	...	...	7	...	...	...	...
Duror	54	109	107	...	...	288	61	109	138	...	...
I											
Thirsk	22	101	*140*	...	...	285	64	115	108	...	...
Willington	54	106	113	...	...	...	55	113	143	...	...
Durham	59	114	...	...	113	276	75	...	142	149	...
Corbridge-on-Tyne	57	115	119	...	...	...	57	114	...	...	...
Blyth	34	109	115	...	...	296	61	...	...	...	...
Lilliesleaf	...	123	118	...	145	267	66	...	134	...	100
J											
Edinburgh	4	113	...	...	...	...	72	109	119	...	...
Kirriemuir	...	110	122	...	...	275	59	...	...	...	...
Durris	60	104	96	...	151	281	60	119	140	162	164
Aberdeen	7	130	...	...	...	...	76	...	...	...	...
Newmill	...	114	116	...	...	271	60	124	118	...	173
Cullen	...	...	*143*	...	...	...	...	...	...	...	...
K											
Invermoidart	56	...	114	...	...	...	...	115	124	...	...
Roshven	56	113	113	...	...	...	...	117	124	...	...
Beauly	52	128	120	...	156	263	57	129	144	...	...
Dingwall	34	128	135	...	...	...	54	116	129	...	...
Inverbroom	...	...	127	...	...	...	...	...	...	...	...
Watten	...	...	...	...	...	...	73	...	136	...	108
Mean Dates for the British Isles in 1902	19 Jan. 19th	105 Apl. 15th	109 Apl. 19th	107 Apl. 17th	143 May 23d	283 Oct. 10th	54 Feb. 23d	102 Apl. 12th	115 Apl. 25th	136 May 16th	167 June 16th
Mean Dates for 1891-1902	Jan. 26th	Apl. 17th	Apl. 21st	Apl. 21st	May 14th	Oct. 12th	Feb. 26th	Apl. 10th	Apl. 16th	May 8th	June 9th

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

***Weston* (E)—The cold spring had some curious effects: some birds desisted from nesting and returned again to flocks. Swifts, swallows, and martins died as late as the middle of May from cold and starvation. Queen wasps numerous. *Brunstead* (E)—21st. Mushrooms gathered from the open ground. 25th. Larch trees browned on north-west side by cold winds. *Palé* (F)—Fruit blossom exceptionally abundant. *Newby Bridge* (F)—10th. Potatoes killed by frost.**

Sulby (F)—Very few cuckoos or corncrakes. Much damage done to fruit blossom by frost. *Ramelton* (G)—Hail and frost did much damage to fruit blossom. *Dumfries* (H)—31st. Not a wasp or white butterfly have been as yet seen. *Moniaive* (H)—3rd. Potatoes blackened by frost, and again on the 10th. Much injury was also done to fruit blossom, especially plums. *Newmill* (J)—Blossom on fruit trees abundant. 28th. Severe gale which did much damage to trees.

JUNE.—*Mawnan* (A)—17th. Everything late, but peas and beans have made excellent growth. *Altarnon* (A)—30th. Flowers on lilac, laburnum, and other hardy flowering shrubs unusually abundant. *Bridgend* (A)—24th. Hay first cut. *St. Arvans* (A)—4th. Hawthorn blossom abundant. *Killarney* (B)—Very few butterflies. *Buckhorn Weston* (C)—The corncrake has been practically an unknown bird here for years, but this year there were a great number. *Churt Vicarage* (C)—12th. Very few butterflies. 17th. First swarm of bees, nearly a month later than the average of past years. *Bagshot* (C)—The leaves on peach trees more blistered than I ever remember. *Berkhamsted* (D)—14th. Dog-rose in flower, the latest date for the same bush for 11 years. *Harpenden* (D)—20th. First ear of wheat seen out of sheath, or 11 days later than its average date in the previous 10 years. *Leominster* (D)—Aphis defoliated red and black currants and gooseberries. Peach and apricot leaves much blistered. *Farnborough* (D)—A great scarcity of orange-tip and small white butterflies. *Macclesfield* (D)—21st. Many ash trees only now in full leaf. *Palé* (F)—Great show of hawthorn blossom. *Betley* (F)—20th. Black-currant bushes infested with aphis. 28th. First hay cut. *Newby Bridge* (F)—23rd. Hawthorn blossom abundant, and now in perfection. *Orry's Dale* (F)—Very few wasps. Bees making very little honey. *Saintfield* (G)—16th. Hawthorn in full flower, blossom very abundant. 20th. Ash trees only now in full leaf. *Jardington* (H)—Hawthorn blossom very abundant. *Thirsk* (I)—29th. Wheat in ear. Haymaking began. *Watten* (K)—Very few small white butterflies this year.

JULY.—*Mawnan* (A)—17th. Good hay crop gathered in good condition. *Coneyhurst* (C)—1st. Cuckoo last heard. *Churt Vicarage* (C)—The worst attack of greenfly on roses I have ever known. 27th. Yesterday's gale did much damage to trees. *St. Albans* (D)—1st. Cuckoo last heard. *Leominster* (D)—4th. Cuckoo last heard. No corncrakes in their usual haunts on low ground, but plentiful at high elevations. *Altofts* (D)—But few butterflies. *Sproughton* (E)—Butterflies of all kinds unusually scarce, but especially the common small white. *Tacolneston* (E)—2nd. Nearly the whole of a good crop of walnuts, the size of hazel-nuts, have fallen off. 21st. Few swallows this year, but the usual number of martins. *Clenchwarton* (E)—Very few butterflies. 12th. Cuckoo last seen. Potatoes diseased. *Loughbrickland* (G)—31st. Instead of the blackberry blossom being as usual nearly over, only about half the flowers are as yet open. *Ramelton* (G)—Very few swallows this summer. *New Galloway* (H)—3rd. Cuckoo last heard. *Jardington* (H)—25th. Potatoes and kidney-beans cut by frost in low-lying ground. *Moniaive* (H)—25th. Potatoes and bracken blackened by frost. *Newmill* (J)—Fruit blossom destroyed by frost.

AUGUST.—*Mawnan* (A)—11th. Harvest began. 13th. Last swift seen. *Altarnon* (A)—31st. Butterflies, house-flies, wasps, and moths numerous late in the season. *St. Arvans* (A)—7th. First corn cut. 27th. Wasps numerous. 30th. Potato disease appearing. *Ovoca* (B)—Very few wasps. *Fordingbridge* (C)—Swallows scarce, but martins plentiful. *Birdham* (C)—Owing to the cold weather in the spring the bees were prevented from gathering honey from the clover, etc., consequently the season has been a very bad one for honey. *Chiddingfold* (C)—27th. A second brood of swallows hatched out. *Churt*

TABLE VI.—ESTIMATED YIELD OF FARM CROPS IN 1902.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
Wheat	15 % O. Av.	13 % O. Av.	10 % O. Av.	10 % O. Av.	10 % O. Av.	4 % O. Av.	1 % O. Av.	3 % O. Av.	22 % U. Av.	15 % O. Av.	10 % O. Av.
Barley	16 % O. Av.	7 % O. Av.	8 % O. Av.	9 % O. Av.	6 % O. Av.	1 % O. Av.	2 % U. Av.	Av.	10 % U. Av.	24 % O. Av.	8 % O. Av.
Oats	16 % O. Av.	18 % O. Av.	14 % O. Av.	13 % O. Av.	8 % O. Av.	7 % O. Av.	2 % O. Av.	6 % O. Av.	8 % U. Av.	14 % O. Av.	12 % O. Av.
Corn Harvest began, average Date	225 (Aug. 13)	222 (Aug. 10)	227 (Aug. 15)	223 (Aug. 11)	236 (Aug. 24)	238 (Aug. 26)	252 (Sept. 9)	257 (Sept. 14)	260 (Sept. 17)	240 (Aug. 28)	238 (Aug. 26)
Beans	14 % O. Av.	15 % O. Av.	22 % O. Av.	17 % O. Av.	4 % O. Av.	10 % O. Av.	Av.	4 % O. Av.	10 % U. Av.	20 % O. Av.	20 % O. Av.
Peas	13 % O. Av.	7 % O. Av.	12 % O. Av.	13 % O. Av.	5 % U. Av.	1 % O. Av.	2 % U. Av.	1 % O. Av.	27 % U. Av.	22 % O. Av.	11 % O. Av.
Potatoes	21 % U. Av.	22 % U. Av.	20 % U. Av.	23 % U. Av.	6 % U. Av.	2 % O. Av.	10 % O. Av.	5 % O. Av.	1 % U. Av.	13 % O. Av.	4 % O. Av.
Turnips	14 % O. Av.	28 % O. Av.	29 % O. Av.	30 % O. Av.	14 % O. Av.	15 % O. Av.	10 % O. Av.	8 % O. Av.	5 % U. Av.	15 % O. Av.	17 % O. Av.
Mangolds	21 % O. Av.	22 % O. Av.	15 % O. Av.	23 % O. Av.	6 % O. Av.	2 % O. Av.	4 % U. Av.	1 % O. Av.	4 % U. Av.	17 % O. Av.	21 % O. Av.
Hay (Permanent Pastures)	26 % O. Av.	48 % O. Av.	33 % O. Av.	24 % O. Av.	14 % O. Av.	17 % O. Av.	1 % U. Av.	1 % O. Av.	11 % U. Av.	5 % O. Av.	18 % O. Av.
Hay (Clover, etc.)	21 % O. Av.	36 % O. Av.	27 % O. Av.	20 % O. Av.	18 % O. Av.	12 % O. Av.	1 % O. Av.	9 % O. Av.	15 % U. Av.	8 % O. Av.	15 % O. Av.

Symbols :—O. = Over. U. = Under. Av. = Average.

The variations from the average in the above-mentioned crops have been obtained from the *Agricultural Returns*, 1902 (*Produce of Crops*), issued by the Board of Agriculture, while the average dates of the Harvest have been derived from returns which appeared in the *Agricultural Gazette*, July 28–August 25 1902.

TABLE VII.—Estimated Yield of Fruit Crops in 1902.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	**C** S.	**D** Mid.	**E** E.	**F** N.W.	**I** N.E.	**H, J,** and **K** W. E. and N.	**B** and **G** S. and N.	
Apples	U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Pears	U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.	Much U. Av.
Plums	U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.	U. Av.	U. Av.	Much U. Av.
Raspberries	Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	U. Av.
Currants	Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	U. Av.
Gooseberries	Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	U. Av.
Strawberries	O. Av.	O. Av.	O. Av.	O. Av.	Av.	Av.	Av.	O. Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, August 2, 1902.

TABLE VIII.—VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1901-02.

WINTER 1901-2.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
December	−1·2	−2·0	−1·5	−2·0	−1·5	−1·8	−1·2	−2·2	−1·8	−2·5	−1·8
January	+2·4	+1·8	+2·8	+2·8	+3·4	+2·2	+1·4	+0·6	+2·8	+0·2	−0·4
February	−4·0	−2·7	−4·0	−4·7	−4·2	−4·5	−3·0	−4·0	−4·2	−4·2	−2·5
Winter	−0·9	−1·0	−0·9	−1·3	−0·8	−1·4	−0·9	−1·9	−1·1	−2·2	−1·6
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	+1·6	−0·2	+1·1	+1·2	+1·6	+0·5	+0·9	0·0	+1·3	+0·6	+0·4
January	−1·5	−1·7	−1·3	−0·9	−1·0	−0·5	0·0	−0·7	−0·9	−1·2	+1·0
February	−1·5	+0·1	−0·5	−0·6	−0·7	−0·6	−0·1	−0·9	−0·4	−1·1	−2·5
Winter	−1·4	−1·8	−0·7	−0·3	−0·1	−0·6	+0·8	−1·6	0·0	−1·7	−1·1
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	− 5	− 1	+11	− 3	+ 8	+ 2	+12	+ 3	+ 1	− 3	− 5
January	− 6	−12	+ 2	+ 7	+ 9	+ 7	− 7	+ 1	− 1	− 2	+ 5
February	+ 1	+ 1	− 3	−10	−11	− 1	−16	−19	− 7	−12	− 4
Winter	−10	−12	+10	− 6	+ 6	+ 8	−11	−15	− 7	−17	− 4

SPRING 1902.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
March	+2·5	+1·7	+2·5	+2·7	+2·0	+2·2	+2·5	+2·0	+2·7	+2·0	+1·7
April	−0·6	−0·8	−0·4	−0·6	−0·8	−1·0	−0·4	−0·6	−0·2	−1·0	−0·6
May	−3·2	−2·5	−3·5	−3·2	−3·2	−3·7	−3·0	−4·0	−2·7	−3·5	−3·7
Spring	−0·4	−0·5	−0·5	−0·4	−0·7	−0·8	−0·3	−0·9	−0·1	−0·8	−0·9
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	+0·2	+0·1	−0·1	−0·2	−0·3	−0·3	+0·5	+1·1	−0·6	−0·6	+2·0
April	−0·6	−0·3	−0·4	+0·2	−0·4	+0·3	+0·4	+0·3	−0·4	+0·1	−0·1
May	0·0	−0·4	+0·5	+0·2	+1·3	+0·7	+1·0	+0·9	+0·9	+0·8	+0·5
Spring	−0·4	−0·6	0·0	+0·2	+0·6	+0·7	+1·9	+2·3	−0·1	+0·3	+2·4
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	−26	−20	−10	− 9	−14	−10	−23	−15	−16	−11	− 8
April	−19	+25	− 5	+30	+14	+62	+72	+22	+53	+29	+37
May	+ 3	−11	−34	−10	−33	+21	−27	−10	−18	− 7	−21
Spring	−42	− 6	−49	+11	−33	+73	+22	− 3	+19	+11	+ 8

+ indicates above the average, − below it.

TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1902.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
June	−1·2	−1·5	−1·5	−1·2	−0·7	−0·7	−1·5	−0·2	−2·0	−2·7	−1·2
July	−1·2	0·0	−0·6	−1·4	−1·2	−2·2	−1·2	−2·0	−1·4	−2·6	−2·6
August	−0·2	−0·5	−0·7	−1·7	−1·5	−2·0	−1·5	−2·0	−2·7	−2·5	−2·2
Summer	−0·9	−0·7	−0·9	−1·4	−1·1	−1·6	−1·4	−1·4	−2·0	−2·6	−2·0
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June	+0·7	+0·1	+1·3	−0·1	+0·7	−0·8	−0·5	−0·7	+0·4	−0·1	+0·9
July	−1·2	−1·1	−1·1	−1·2	−0·6	−0·6	+0·8	0·0	−0·4	−0·4	−0·5
August	−0·8	−0·4	+1·0	+0·7	+0·7	−0·8	−1·4	−0·6	0·0	−0·5	−1·0
Summer	−1·3	−1·4	+1·2	−0·6	+0·8	−2·2	−1·1	−1·1	0·0	−1·0	−0·6
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	−50	−37	−10	−22	−8	−31	−34	−54	−7	−46	−13
July	+2	+15	+12	−2	+4	−9	+4	−1	−26	−47	−27
August	−15	+18	−35	−26	−18	+28	+6	+20	−13	−14	+4
Summer	−63	−4	−33	−50	−22	−12	−24	−35	−46	−107	−36
AUTUMN 1902. *Temperature.*											
	°	°	°	°	°	°	°	°	°	°	°
September	+0·5	+1·0	+0·2	−0·2	+0·2	+0·2	+1·2	+0·7	−0·2	0·0	+0·5
October	+0·6	+1·4	0·0	+0·6	+0·4	+0·6	+1·6	+1·4	+1·0	+0·4	+1·4
November	+1·2	+1·7	+1·0	+0·7	+0·5	+1·0	+1·7	+2·0	+1·7	+2·5	+4·0
Autumn	+0·8	+1·4	+0·4	+0·4	+0·4	+0·6	+1·5	+1·4	+0·8	+1·0	+2·0
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September	−0·9	−0·6	−0·7	−0·8	−0·6	−2·1	+0·4	+0·3	−1·4	−1·2	−0·6
October	−1·6	−1·9	−1·4	−0·6	−1·5	−0·8	−1·8	−1·1	−0·9	−1·5	−0·6
November	+0·3	+1·5	−0·3	−0·3	−1·3	−1·2	+0·5	+0·2	−1·2	−0·7	−2·6
Autumn	−2·2	−1·0	−2·4	−1·7	−3·4	−4·1	−0·9	−0·6	−3·5	−3·4	−3·8
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September	+18	+13	+12	+24	+19	+25	+11	−20	0	−28	−14
October	−15	−29	−37	−33	−34	−10	−21	−11	−23	−17	+11
November	−2	−11	−4	+1	0	+11	+1	−14	−3	−6	+10
Autumn	+1	−27	−29	−8	−15	+26	−9	−45	−26	−51	+7

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

TABLE IX.—SUPPLEMENTARY OBSERVATIONS IN 1902.

PLANTS.

WINTER ACONITE.

Station.	District.	Date.
Mawnan	A	Jan. 6.
Aberystwith	A	„ 9.
Bembridge	C	„ 9.
Bagshot	C	Feb. 22.
St. Albans (Worley Road)	D	Jan. 20.
Berkhamsted	D	„ 14.
Ripley	D	„ 3.
Hodsock	D	Feb. 22.
Clenchwarton	E	Jan. 11.
Saintfield	G	„ 20.

BIRDS.

WHEATEAR (first seen).

Station.	District.	Date.
Bridgend	A	April 6.
Aberystwith	A	March 22.
Bembridge	C	„ 21.
Ripley	D	April 29.
New Galloway	H	„ 8.

CHIFF-CHAFF (first heard).

Station.	District.	Date.
Altarnon	A	April 12.
Aberystwith	A	March 22.
Berkhamsted	D	„ 28.
Ripley	D	April 8.
Edgeworthstown	G	„ 4.
Loughbrickland	G	„ 14.
Antrim	G	„ 1.

CORNCRAKE (first heard).

Station.	District.	Date.
Altarnon	A	June 18.
Bridgend	A	May 12.
Ovoca	B	April 28.
Beeston	D	June 6.
Ripley	D	May 10.
Enniskillen	G	April 18.
Loughbrickland	G	„ 25.
Antrim	G	„ 21.
Altnafoyle	G	„ 27.
Dumfries	H	May 29.
Corbridge	I	April 25.
Inverbroom	K	May 9.
Watten	K	„ 17.

SWIFT (first seen).

Station.	District.	Date.
Mawnan	A	May 14.
Brixham	A	April 24.
Ovoca	B	May 8.
Churt Vicarage	C	„ 11.
Harefield	D	„ 18.
St. Albans (Worley Road)	D	„ 6.
Leominster	D	„ 4.
Ripley	D	„ 15.
Odsey	E	„ 19.
Lexden	E	„ 17.
Antrim	G	„ 7.
New Galloway	H	„ 22.
Corbridge	I	„ 8.

Vicarage (C)—25th. Harvest very late—only just beginning generally. *Bagshot* (C)—Wasps' nests numerous. Fruit ripened very slowly at end of month. Potatoes diseased. *Weston Green* (C)—Summer fruits wanting in flavour. *Beckford* (D)—14th. First wheat cut. *Harefield* (D)—3rd. First oats cut. *Farnborough* (D)—A bad season for honey. *Hodsock* (D)—20th. Harvest began—a month later than last year. Very few wasps. *Market Weston* (E)—Great quantities of mushrooms owing to the wet weather. *Tacolneston* (E)—19th. First wheat cut. Potato disease prevalent. 31st. Two or three swallows' nests in a shed here, one at least with young birds in it. *Clenchwarton* (E)—12th. Harvest began. *Betley* (F)—30th. First wheat cut. *Cronkbourne* (F)—13th. Harvest began. Wasps very scarce. *Sulby* (F)—Insects, especially Lepidoptera, very scarce this year, also wasps. Have seen no humming-bird hawk-moths this summer. *Antrim* (G)—10th. Swift last seen. Scarcely any wasps, and virtually no house-flies. *Ramelton* (G)—Very few wasps or house-flies. A very bad season for honey. *Jardington* (H)—Very few house-flies. *Moniaive* (H)—22nd. Corn harvest began. *Kirriemuir* (J)—12th. Scarcely any wasps. A bad honey year. *Newmill* (J)—12th. Swift last seen. *Dingwall* (K)—The honey harvest a failure.

TABLE X.—LEAFAGE AND DEFOLIATION OF LIME TREES IN THE "GARDEN" OF THE BANK OF ENGLAND, LONDON, E.C.

Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.	Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.
1888	April 20	October 26	1897	March 23	October 25
1889	March 30	" 21	1898	April 5	" 27
1890	" 31	" 28	1899	" 4	" 20
1891	" 18	" 29	1900	" 6	" 29
1892	" 30	" 24	1901	" 9	" 26
1893	" 14	" 20	1902	March 27	" 20
1894	" 27	" 22			
1895	" 23	" 31	Means	March 30	October 24
1896	" 24	" 17			

SEPTEMBER.—*Brixham* (A)—1st. Butterflies of all kinds have been very scarce. *Westward Ho* (A)—Very few peaches or plums, owing to cold winds in the spring destroying the blossom. *Clifton* (A)—An unusually large number of wasps' nests were taken near Abbot's Leigh, Somerset. *Aberystwith* (A)—Butterflies remarkably scarce. A poor crop of acorns, but much beech-mast and haws. *Churt Vicarage* (C)—14th. Scarlet runner beans cut by frost in lower part of parish. 18th. Potatoes poor and much diseased. *Churt* (C)—13th. Ring-ouzel first seen. *Bagshot* (C)—25th. Harvest completed. Wasps numerous. Very few mushrooms. *Weston Green* (C)—10th. Severe hailstorm which did great damage to plants and fruit. *Harefield* (D)—4th. Still carting hay. 7th. Blackberries and sloes ripe. *Harpenden* (D)—There were good grain crops, but the excessive rain of August considerably damaged the corn after it was cut, and much of it sprouted while standing in shock. *Farnborough* (D)—Very few earwigs or daddy-longlegs. *Hodsock* (D)—26th. Harvest finished. *Macclesfield* (D)—27th. Lime-tree leaves began to fall. In 1901 the same trees began to shed their foliage on July 23. *Brunstead* (E)—Apples small and few. *Clenchwarton* (E)—Bad honey harvest. 20th. Corn harvest ended. *Palé* (F)—Very few wasps. *Newby Bridge* (F)—1st. The hay harvest only now at an end. *Orrys Dale* (F)—No seed on sweet-peas this year. *Lilliesleaf* (I)—Noticed an apple tree in an orchard covered with fruit, and with here and there blossoms. *Kirriemuir* (J)—Apples and pears numerous, but small and flavourless. *Newmill* (J)—Have not seen a wasp this month.

OCTOBER.—*St. David's* (A)—Completion of corn harvest delayed through frequent rains. *Buckhorn Weston* (C)—Hazel nuts unusually plentiful. *Coneyhurst* (C)—9th. Sand-martin last seen. *Churt Vicarage* (C)—Acorns few and small, also Spanish chestnuts. Hazel nuts abundant. *Churt* (C)—10th. Autumn tints very fine. *Bagshot* (C)—Scarcely any acorns. *Watford* (D)—1st. Apples mostly very small and blighted. *Brunstead* (E)—7th. Fieldfare first seen. 10th. First woodcock seen. *Clenchwarton* (E)—Autumnal tints fine. *Palé* (F)—Wild fruits, acorns excepted, very abundant. *Newby Bridge* (F)—8th. Dahlias killed by frost. *Durris* (J)—2nd. Harvest began. 29th. The autumnal tints are now at their best. Hips and mountain-ash berries numerous. *Watten* (K)—10th. Dahlias killed by frost.

NOVEMBER.—*Mawnan* (A)—24th. 49 different sorts of flowers out in this garden. Wasps still very numerous. *Altarnon* (A)—18th. Dahlias killed. 30th. Very poor covies of partridges. *Tiverton* (A)—4th. Gathered a quart of ripe blackberries. 14th. 84 different wild flowers and 62 different garden flowers have been gathered this month. *St. Arvans* (A)—18th. The leaves are still on many of the trees, especially elms and oaks. *Skibbereen* (B)—29th. Dahlias

first touched by frost. *Killarney* (B)—Dahlias still in perfection at end of month. *Ovoca* (B)—30th. 5 different kinds of roses in bloom. *Bembridge* (C)—Many deciduous trees making fresh growth and flowering a second time. Second crops of plums, pears, apples, and raspberries. *Botley* (C)—28th. The oak trees still retain their foliage. *Chiddingfold* (C)—26th. Many winter moths captured in orchard. *Churt Vicarage* (C)—13th. Dahlias killed by frost—the latest date since 1884. *Churt* (C)—19th. Holly-berries abundant. *Bagshot* (C)—7th. All the beech leaves have fallen. 15th. Heliotropes and dahlias still in bloom. 17th. Dahlias killed by frost. 30th. Not many leaves remain on the oaks. *Weston Green* (C)—30th. Some roses still in bloom. *Beckford* (D)—The foliage on the elms still green. *Watford* (D)—14th. Gathered a lovely lot of roses. *Berkhamsted* (D)—12th. Exhibited at the local chrysanthemum show a large number of choice rose blooms and 54 different species of flowers gathered from the open ground in my garden. 21st. Dahlias killed by frost—a fortnight later than the average date of their destruction in the previous 17 years. *Ross* (D)—18th. Dahlias killed by frost. *Farnborough* (D)—23rd. Gathered beautiful roses up to this date. *Northampton* (D)—15th. Peas and French beans in flower. 24th. Nasturtiums have lasted till now—a very rare occurrence. *Beeston* (D)—14th. Tea-roses still blooming. *Hodsock* (D)—17th. Filled 15 glasses with roses. *Macclesfield* (D)—8th. Until this date some young ash trees were in full leaf and quite green. *Tacolneston* (E)—20th. Fieldfares first seen. 21st. Dahlias killed by frost. *Brunstead* (E)—18th. Gathered a good dish of garden peas. 22nd. Dahlias killed by frost. *Clenchwarton* (E)—26th. 20 roses out on one bush. *Palé* (F)—22nd. Dahlias killed by frost. *Cronkbourne* (F)—30th. Nasturtiums still in flower against a wall. *Edgeworthstown* (G)—30th. Roses blooming until this date. *Saintfield* (G)—25th. Roses, sweet-peas, and dahlias still in flower. *Antrim* (G)—At the end of the month some roses still in flower. *Altnafoyle* (G)—5th. Dahlias still in flower. *Ramelton* (G)—Roses remained in bloom throughout the month. *Lilliesleaf* (I)—30th. Gathered some apple blossom. *Durris* (J)—20th. Harvest finished. 31st. Gathered ragwort, black knapweed, and several other wild flowers. *Newmill* (J)—30th. Many flowers still out in the gardens. *Dingwall* (K)—The ivy failed to bloom.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) thanked Mr. Mawley for his interesting and valuable paper. He believed the Swiss naturalist, De Candolle, was the first to take phenological observations; he had written much on the influence of meteorological conditions on the life-history and growth of plants. Could Mr. Mawley in any way explain the often unaccountable difference in the abundance of crops? We have neglected the investigation of such questions because, as a nation, we are comparatively little interested in agricultural pursuits; but if, in the future, we are thrown more on our own resources in this respect, we shall come to learn the value of such scientific study from a utilitarian point of view. With regard to the variation in the dates on which migratory birds arrive in this country, might it not be that previous experience of our uncertain climate quickens the birds' instinct, not to arrive before their insect food awaits them. Severe winters are favourable to insect life; in mild weather the ova or pupæ are liable to come out too soon and so be destroyed by following bad weather, or perish from lack of plant food.

Mr. R. G. K. LEMPFERT, at the request of Dr. Shaw, who was unable to be present, exhibited a table summarising the aggregate weekly values of accumulated temperature above 42° for the district England South, as published in the *Weekly Weather Report* issued by the Meteorological Office. The table was

drawn up with a view to facilitating the comparison for successive years of the dates of occurrence of phenological events, and the dates of arriving at constant amounts of accumulated temperature (the latter being reckoned from the commencement of the year) in order to test the theory, originated by De Candolle, that a constant amount of accumulated temperature is a dominant factor in arriving at a particular stage in the growth of a plant. He pointed out that as the table gave the mean values for a large district, based on observations made at a number of stations in it, it would be necessary to arrange the phenological data also to represent the district as a whole in making a comparison by its means.

Mr. H. SOUTHALL remarked that no one could be more interested in or more obliged to Mr. Mawley for so much work in considering and arriving at his conclusions. He found that Mr. Mawley's observations agreed with his own. Those who grow plants or crops know that they have not to depend alone upon the weather at one particular period, but also upon the state of the soil and the warmth or coldness of the previous season. Foreigners, as a rule, made closer observations of these matters. He thought perhaps the calendar should begin in October rather than in January, for agricultural purposes. We had been suffering for fifteen or sixteen years more or less from drought in England, and the grass and root crops had thereby been specially affected. In the past year there had been plenty of rain in the sowing season, but the average was very little above the normal. The year had been most favourable for grain but had been bad for hops. Fruit-growers did not seem to study factors enough. He was very glad after thirty or forty years' experience to find that Mr. Mawley's observations confirmed his own.

Mr. R. H. CURTIS referring to what had been said regarding accumulated temperature, thought that method of dealing with temperature observations would afford a ready means of ascertaining, with a fair approach to accuracy, what was the minimum amount of heat required to mature cereal and other crops. From a study he was making of some data supplied to him from Rothamsted, he had found that the percentage of variation from the mean in the time which elapsed between sowing and reaping was far greater than the variation in the amount of accumulated temperature. It was, however, much to be regretted that no record had been kept, either at Rothamsted or at any other place with which he was acquainted, of the dates of flowering and of ripening of the plants, in addition to the dates of sowing and of reaping. A moment's thought could make it clear that owing to unfavourable weather, or other causes, there might be a considerable difference between the dates of ripening and of cutting a crop of wheat, or barley; and it would probably serve a useful purpose if the dates of different stages of plant growth were recorded at the Scientific Agricultural Schools and farms which were now established in various parts of the country.

Mr. C. HARDING remarked that the results tended in every way to enhance the value of the means obtained by continuous records. For the first few years the mean was poor (as the results did not extend over a sufficient interval of time to give a fair average), but the value of the records had now become very great. Reference was made in the paper to the difference in farm and fruit crops, and Mr. Mawley stated that the farm crops being good was owing to the ground being favourable for sowing and planting. Every one knew that for the previous eight years there had been a great deficiency of rain. Although the months of January and February had shown of recent years a very deficient rainfall, in December just the reverse had occurred and that month had for ten out of fourteen years been in excess of its average. It would be important to note these details when making calculations on the weather and crops, and Mr. Mawley's paper would help very materially in this respect. It is necessary to

bear in mind maximum and minimum temperatures, and that a humid atmosphere, little sunshine, and few hot days throughout the summer could not fail to affect crops. Although we might deplore the past bad summer, it was interesting to compare the health statistics with those of the weather. It would appear that the mild winter and cool, rainy summer produced a very healthy effect, and the total deaths in London alone were nearly 7000 below the average in consequence. Mr. Mawley was to be thanked for his labour and perseverance in going into the matter as he had done.

Mr. W. MARRIOTT exhibited some wind-roses and temperature diagrams for the year 1902, and mentioned that May had been one of the coldest of the century, while June also had suffered from a quite remarkable spell of cold weather which lasted up to the time originally appointed for the coronation, when it became very fine and mild. Altogether it had been a very unseasonable period.

Mr. E. MAWLEY replied that the President's remarks about the destructive effect upon insect life of a mild, and more especially of a variable winter, as compared with a continuously severe one were perfectly true. He thought this might in a great measure account for the scarcity of insects last year, for during the warm weather in January many insects were no doubt tempted to leave their safe winter quarters only to fall victims to the keen frosts which suddenly set in afterwards. He did not like to express any definite opinion as to the practical value of accumulated temperatures in this country, as he had not been able to examine into the question as closely as he could wish. He could only say that, judging by the Rothamsted tables of accumulated temperatures alone, he did not think as affecting the growth of wheat that the results were sufficiently consistent to allow of much dependence being placed upon them. In reply to Mr. Southall, as to the phenological year commencing with October, he said there were advantages and disadvantages in any date that might be selected, but the beginning of the winter he considered on the whole the best time, as vegetation generally had then entered upon its resting period. Moreover, the division of the year into the usual four seasons was one which was likely to be the most readily understood. He thought that Mr. Curtis's idea of accurate observations of the progress of the different farm crops being taken at selected agricultural stations an excellent one. The diagrams of temperature shown by Mr. Marriott were very interesting, as one could tell almost at a glance to what extent the growth of farm and garden crops were likely to have been influenced by the warm and cold periods, the length and intensity of which were so clearly represented. If combined with similar diagrams of rainfall they would be still more valuable.

JAMES GLAISHER, F.R.S.

Born April 7, 1809. Died February 7, 1903.

Quart. Journ. Roy. Met. Soc. vol. xxix. pl. 3. *From Photo. by Elliott & Fry.*

James Glaisher, F.R.S.

1809–1903

(Plate III.[1])

JAMES GLAISHER was born at Rotherhithe on April 7, 1809. The year 1829 found him engaged on the principal triangulation of the Trigonometrical Survey of Ireland, and in the performance of this duty he was often compelled to remain, sometimes for considerable periods, above, or enveloped in cloud. He was thus led into studying the colours of the sky, the delicate tints of the clouds, the motion of opaque masses, and the forms of the crystals of snow.

On leaving the Irish Survey he was, at the beginning of the year 1833, appointed by Prof. Airy an Assistant at the Cambridge Observatory. On December 4, 1835, Prof. Airy (then Astronomer Royal) appointed Mr. Glaisher an Assistant at the Royal Observatory, Greenwich, the Admiralty approving the appointment on December 10.

On the establishment of the Magnetic and Meteorological Department in November 1840, Mr. Glaisher was transferred from the Astronomical Department thereto, and appointed Superintendent, a post which he held until his retirement in 1874.

Very soon he began to turn his attention to the subject of dew and radiation of heat at night, and determined to make special observations thereon. As he found it very difficult to procure reliable and suitable thermometers, he consulted Mr. Watkins on the subject, and induced him to make a special set for the purpose. The essentials laid down by Mr. Glaisher for the construction of these were: 1. That the scale be marked on the tube; 2. That the points corresponding to the freezing and boiling of water be exactly determined; 3. That the column of mercury which fills the tube be exactly uniform throughout; and 4. That the thermometers should be of the most delicate kind and the most sensitive to the variations of heat. These instruments were made in 1842, and Mr. Glaisher forthwith proceeded to make observations on nocturnal radiation from various bodies placed on or near the surface of the earth, on long and short grass, mould, cotton-wool of various colours, flannel, wood, and other substances. He communicated these observations to the Royal Society in a paper which was printed in the *Philosophical Transactions* in 1847.

When the Magnetic and Meteorological Department at the Royal Observatory was established, it was the custom to take observations every two hours, day and night. Mr. Glaisher was soon impressed with the diurnal range in the various elements, and that readings were above or below the mean for the day according to the hour at which they were taken. And so when several years' observations had been made he prepared his Tables of *Corrections to Meteorological Observations for Diurnal Range*, which were based upon the results of these 2-hourly observations.

He also directed his attention to the most effective and simple method of determining the true hygrometric conditions of the air. He

[1] We are indebted to the Secretary of the Aeronautical Society for the loan of the block of Mr. Glaisher's portrait.—EDITORS.

held this to be best performed by the employment of the Dry and Wet bulb thermometers, which combined, may be considered as but one instrument, and which were found to give results identical with Daniell's Hygrometer, over which they possess the great advantage of requiring water only, and giving continuous observations. Upon the results of his simultaneous determination of the temperature of the dew point by Daniell's Hygrometer and the Dry and Wet bulb thermometers he compiled his *Hygrometrical Tables adapted to the use of the Dry and Wet Bulb Thermometer*, 1847, which have been, and still are, the accepted authority by British meteorologists for hygrometrical reductions. These Tables have passed through eight editions.

At the request of the Registrar-General, Mr. Glaisher about 1846 began to take steps to collect Meteorological Observations for inclusion in the *Quarterly Returns of Marriages, Births, and Deaths.* He induced a number of gentlemen to equip meteorological stations, and visited many of them, testing the instruments and giving instruction in the method of observing in order to secure as much uniformity as possible. With the year 1847 he commenced his "Remarks on the Weather during the Quarter," which was a prominent feature in these Returns ever since.

It may be interesting to give Mr. Glaisher's own account as to the manner in which his first connection with the Registrar-General commenced. In his evidence before the Royal Commission on Scientific Instruction in 1874, he said: "The Registrar-General had published the mean temperature at York as being five degrees higher than the mean temperature at London; in consequence of which I wrote to him, telling him of the physical impossibility of such being the case, and he then told me that he had no one in his office who could reduce the observations, and no one who could prove whether they were correct or no. Having been educated as an astronomer, and having had the Meteorological Department placed in my hands, I had been desirous of ascertaining the general accuracy of meteorological instruments in general use. For that purpose I had gone all over England, Ireland, and Scotland to see the best observers who were taking observations, and I found that of the thermometers the most accurate were three-tenths of a degree wrong at 32°, and three degrees wrong at 90°, in both cases reading too high, and that barometers were very frequently a quarter of an inch in error. Mr. Sheepshanks, in the years 1840 and 1841, brought out his standard thermometer, which is still the standard, and I endeavoured to bring into general use instruments very nearly free from errors. The instrument-makers then worked with me, and the consequence was, that at the time the Registrar-General spoke to me, I knew a large number of persons who, I thought, would take observations; and, knowing a good number of Cambridge men, I thought that clergymen would unite with me, and would help in establishing a system of truthful observations. Thereupon I travelled over the country and induced some 50 or 60 gentlemen of education and position to engage in the toilsome work of daily observations, and they have done so for these 30 years. I feel it a great pleasure and pride to think that I have successfully organised a system which had always previously failed. That system I have continued from that time to the present."

Mr. Glaisher continued to supply these quarterly Reports on "The

Meteorology of England" to the Registrar-General up to March 1902. He did not receive any remuneration for his services in the preparation of these Returns until the end of 1853, when H.M. Treasury sanctioned the payment of a lump sum of £150 for past years, and a small annual allowance from that date; but this was discontinued in 1875, since which time Mr. Glaisher did the work entirely gratuitously. It may be mentioned, however, that the Council of the Meteorological Society for about twenty years allowed Mr. Glaisher, while Secretary, the sum of £52 per annum for an assistant, who rendered him great service in the reduction of the observations for the Registrar-General's Returns.

In the U.S. *Monthly Weather Review* for May 1897 there is reprinted a letter dated July 8, 1850, from Mr. Glaisher—whom Prof. Cleveland Abbe names "The Nestor of Meteorologists"—to Prof. J. Henry, the Secretary of the Smithsonian Institution, describing what was being done in this country in regard to meteorological observations. From this we learn that in 1849 the proprietors of a London newspaper, the *Daily News*, decided upon collecting and publishing reliable and synchronous daily reports of the direction and strength of the wind, and of the state of the weather at 9 a.m. the previous day, from a number of railway stations all over the country and parts of Scotland. They entrusted Mr. Glaisher with the organisation, and, as nearly all the railway companies gave him a free pass over their lines, he visited the stations, fixed the compass points, and instructed the stationmasters in the method of observing. The first of these Weather Tables was printed in the issue for June 14, 1849.

It will be evident that he took a great interest in the supply of proper instruments to the observers, and this consequently soon led him to induce the makers to exercise greater care in the manufacture of barometers, thermometers, and rain-gauges. He had most of the instruments sent to him for examination and verification before being forwarded to the observers. He thus became the recognised authority for the verification of meteorological instruments, even until a considerable time after the Kew Observatory had taken the matter up.

He was a Juror in the Class of Philosophical Instruments at the International Exhibition in 1851, and as such was greatly impressed with the value of Messrs. Negretti and Zambra's maximum thermometer, which was first exhibited there.

He early sought data for obtaining constants for temperature, and so worked up the thermometrical observations made at the Apartments of the Royal Society from 1774-81 and 1787-1843, and published in the *Philosophical Transactions*, 1849, the Mean Temperature of each month for those years. In a second paper he combined the Royal Society's thermometrical observations with those made at the Royal Observatory, Greenwich, and also filled up the gap in the early years, thus making a complete set extending from 1771 to 1849.

In 1857 Mr. Glaisher published the first of his papers "On the Mean Temperature of every Day in the Year at the Royal Observatory, Greenwich," which embraced the period 1814-1856; his second paper in 1865 brought it up to 1863; and his third paper in 1876 added another ten years, bringing the period up to 1873.

In 1865 he dealt with the "Secular Increase of Mean Temperature," and came to the following conclusions:—1. That our climate has altered in the last 100 years; 2. That the temperature of the year is 2° warmer now than it was then; 3. That the month of January is 3° warmer; and 4. That the winter months are all much warmer, and every month of the year seems to be somewhat warmer than before. It is hardly necessary to point out that with instruments thoroughly comparable in every respect, and with observations extending to the present time, somewhat different conclusions might have been arrived at.

During the severe weather at the beginning of the year 1855 Mr. Glaisher carried out an extensive investigation on the structure and formation of Snow Crystals, and with the aid of Mrs. Glaisher drew a series of 151 different forms of these, which were printed in the fifth *Report of the Council* of this Society, 1855.

At the request of the General Board of Health he entered into an investigation of the Meteorology of the years 1832, 1849, and 1854, in relation to Cholera in the Metropolitan districts, and in 1855 presented an elaborate Report on the subject. He found that the three epidemics were attended with a particular state of atmosphere characterised by a prevalent mist, thin in high places, dense in low. During the height of the epidemic, in all cases, the reading of the barometer was remarkably high, and the atmosphere thick. In 1849 and 1854 the temperature was above its average, and a total absence of rain, and a stillness of air, amounting almost to calm, accompanied the progress of the disease on each occasion. In places near the river the night temperatures were high, with small diurnal range, a dense, torpid mist, and the air charged with many impurities arising from the exhalations of the river and adjoining marshes, a deficiency of electricity, and a total absence of ozone, most probably destroyed by the decomposition of the surrounding organic matter.

Mr. Glaisher was for many years a regular attendant at the annual Meetings of the British Association, and served on several of its Committees. On the appointment of the Committee on Observations of Luminous Meteors in 1860 he was made Chairman, and continued as such for more than twenty years.

At the request, and under the auspices, of one of the British Association Committees he made a large number of balloon ascents to as great a height as possible, in order to determine the temperature and humidity of the air at different elevations, the rate of decrease of temperature with increase of elevation; also to investigate the distribution of water, in the invisible form of vapours, in the air below the clouds, in the clouds, and above them, at different elevations.

These balloon ascents were made in conjunction with Mr. H. Coxwell, the aeronaut, and carried out in the years 1862-66. The most famous ascent was that from Wolverhampton on September 5, 1862, when the great altitude of about 7 miles from the earth was reached. Mr. Glaisher became insensible at the height of about 29,000 ft., and Mr. Coxwell's hands were so frozen that he was only able to open the valve by seizing the cord with his teeth and dipping his head several times, until the balloon took a decided turn downward.

In 1869 Mr. Glaisher also made about thirty ascents in Mons.

Giffard's great captive balloon at Chelsea, and the result of the observations which he then made on the temperature and humidity of the air up to 1000 ft., as well as simultaneous observations at the Royal Observatory, Greenwich, were communicated to the British Association the same year.

A popular book describing the balloon ascents of Mr. J. Glaisher, C. Flammarion, W. de Fonvielle, and G. Tissandier, under the title of *Voyages Aériens*, was published in Paris in 1869, and in 1871 an English translation of the same was published under the title of *Travels in the Air*.

At the request of the Commission of Inquiry into the Sanitary State of the Army in India, Mr. Glaisher in 1863 prepared an elaborate Report on the Meteorology of India in relation to the health of the troops there stationed. In this he included the results of all the meteorological observations made in India which he could procure. These, however, did not appear to be very satisfactory, for he concludes his Report as follows: "I cannot help expressing the hope that future meteorological observations in India may be carried out under some general system on a uniform plan, both with respect to instruments, their position and general instructions."

Mr. Glaisher had no doubt seen in the course of his organisation of the staff of observers for the Registrar-General that the science of Meteorology would be greatly advanced if the observers and others interested in the subject were federated into a Society, and so on April 3, 1850, he, with the co-operation of Dr. J. Lee, F.R.S., Mr. S. C. Whitbread, and a few others, founded the British (now Royal) Meteorological Society. He held the office of Secretary from 1850 till 1872, except for the two years, 1867-68, when he was President, and was a Member of the Council in 1873. He took a great interest in the welfare of the Society, and edited its publications during the greater part of the period.

He discussed many of the observations made at the Royal Observatory, Greenwich, and communicated numerous papers thereon to this Society, among them being "The Fall of Rain on every Day of the Years 1815-69," "Meteorological and Physical Effects of the Solar Eclipse of March 15, 1858," and "Mean Pressure of the Atmosphere on every Day of the Years 1841-58." He not infrequently gave evidence before Parliamentary Committees on the subject of rainfall and evaporation in connection with Bills dealing with Water Supply.

He was a Director of several Gas and Water Companies, of more than one of which he was Chairman, and he maintained his interest in these until the end of his life.

Mr. Glaisher was elected a Fellow of the Royal Society in 1849. He was the first President of the Royal Microscopical Society, 1865-68, and was President of the Photographic Society, with the exception of one year, from 1869 to 1892. He was a Member of the Council of the Aeronautical Society from its foundation in 1866 until the day of his death. He was also for many years a Member of the Committee of the Palestine Exploration Fund, and in 1880 he became chairman to the same. On entering his ninetieth year, April 7, 1898, the Committee of the Fund presented him with an Address of congratulation.

On his retirement from the Royal Observatory Mr. Glaisher removed

from Blackheath to South Croydon, where he resided until his death on February 7, 1903, at the age of ninety-three years.

WM. MARRIOTT.

At the Meeting of the Society held on Wednesday evening, February 18, 1903—

THE PRESIDENT (Capt. D. WILSON-BARKER) said: By the lamented death of Mr. James Glaisher, F.R.S., the Society loses one of its founders, and Meteorology one of its most devoted and eminent exponents. No one in this country, except his great predecessor in the science, Luke Howard, has done more to develop this branch of Natural History. Mr. Glaisher began his meteorological studies at the age of twenty, while engaged in Ordnance Survey work in Ireland. His subsequent connection with the Cambridge Observatory and with the Royal Observatory, Greenwich, afforded him ample opportunities for pursuing his investigations. The British Association had made aerial experiments from 1843, but with little practical results, until Messrs. Coxwell and Glaisher in 1862 made their memorable ascent from Wolverhampton and reached the height of 37,000 ft. Between 1862 and 1869 Mr. Glaisher made 29 ascents, with the resulting acquisition of much valuable data.

This Society, which took shape and held its early meetings in the house of Dr. Lee at Hartwell, would appear to have been founded chiefly through the initiative of Mr. Glaisher; he was its Secretary, and retained the post—save for the two years 1867-68, when he was President—until 1872, and his interest in its progress and development never ceased.

Mr. A. BREWIN, as one of the oldest Fellows in the Society, and a personal friend of the late Mr. Glaisher, thanked the President for giving him the opportunity of saying a few words on the death of Mr. Glaisher, and of proposing the condolences of the Society to his son, Dr. J. W. L. Glaisher. It might be said that during its early years—apart from being, in conjunction with Dr. Lee, its Founder—he *was the* Society; and but for his unceasing energy and work, the Society might have met with the fate of many another, and ceased to exist. Mr. Glaisher had kept it going until it was enabled to stand by itself, and too much appreciation could not be expressed of his and Dr. Lee's labours. Mr. Brewin had great pleasure in moving the following resolution:—

"The Council and Fellows of the Royal Meteorological Society have heard with regret of the death of Mr. James Glaisher, F.R.S., who was one of the Founders of the Society. He held the office of Secretary from 1850 until 1872, excepting for the two years 1867-68, when he was President; and he was a Member of Council in 1873.

"The Council and Fellows desire to record their high sense of the valuable assistance which Mr. Glaisher rendered to the Society in the early years of its existence, and of his great and long-continued service in the promotion of the science of Meteorology.

"The Council and Fellows desire to express their sympathy with his son, Dr. J. W. L. Glaisher, F.R.S."

Mr. R. INWARDS said that perhaps, as one of the older Fellows of the Society, who knew Mr. Glaisher personally, when he was one of the most prominent, as well as the earliest of the Fellows, he (Mr. Inwards) might add his tribute of recognition of the invaluable services rendered by Mr. Glaisher both to the Society and the science of Meteorology generally. Mr. Glaisher had also held the chair for many years at the Photographic Society, where he was no less appreciated and beloved. Mr. Inwards heartily seconded the resolution of condolence.

Mr. H. SOUTHALL said his only claim to speak on the occasion was that of having had the honour of being introduced by Mr. Glaisher to the Society forty years previously, when its condition was very different from what it now is. He thought that the great change for the better which had occurred in the interval should by no means decrease the value in our eyes of what the Society achieved in those early days, and with more limited means. He was glad to have the opportunity of being present once more at a Meeting of the Society, and of saying a few words about Mr. Glaisher.

Mr. W. MARRIOTT said that he should like to testify to the thanks which the Society owed the late Mr. Glaisher for his valuable work. More especially was he glad to have the opportunity of speaking, as Mr. Glaisher had been his old master in the Magnetic and Meteorological Department of the Royal Observatory, Greenwich, and Mr. Marriott's present appointment at the Royal Meteorological Society was no doubt due in some measure to this influence.

On looking back he was more and more impressed with the great value to meteorological science of Mr. Glaisher's work. It was easy enough in these days to start and equip a Meteorological Station, but it was not so sixty years ago, when Mr. Glaisher undertook to supply the Registrar-General of Births and Deaths with meteorological statistics from a number of stations in various parts of the country.

When the Magnetic and Meteorological Department of the Royal Observatory was started in 1840, Mr. Glaisher was transferred from the Astronomical Department, and appointed Superintendent. In those days there were no self-recording instruments, and so eye-observations were taken every two hours, day and night. Mr. Glaisher, in taking his turn in observing, would become impressed with the diurnal range of the various elements, and of the character and aspect of the sky. When several years' observations had been carried on, he compiled his Tables of *Corrections for Diurnal Range*, which were intended to allow observers to correct their observations made at any particular hour in the day, in order to bring them approximately to a mean value. It should be mentioned, however, that the diurnal range corrections were only applicable to stations which were under similar conditions to Greenwich. In the old days there were no good thermometers, so Mr. Glaisher induced some of the instrument-makers to manufacture a better class of instrument. He became the recognised authority for the verification of barometers and thermometers, even until some years after the Kew Observatory had taken up the matter of verification of instruments.

Mr. Glaisher was perhaps best known to the public by the balloon ascents which he made for the British Association in 1862-66 in conjunction with Mr. H. Coxwell, the aeronaut. The most remarkable ascent was that from Wolverhampton on September 5, 1862, when they reached a height of about 7 miles from the earth's surface. Mr. Glaisher became insensible at 29,000 ft., and Mr. Coxwell's hands were so frozen that he was only able to open the valve of the balloon by grasping the rope with his teeth and bobbing his head several times, until the balloon began to descend.

In his personal appearance and bearing Mr. Glaisher kept to the old style, and was strong and vigorous, and hardly altered in any way until his death, at ninety-three years of age.

The Royal Meteorological Society would probably never have become what it had but for Mr. Glaisher's unceasing efforts in the early years of its existence.

THE PRESIDENT then put to the Meeting the resolution, which was unanimously adopted.

Temperature and Rainfall at Rockhampton, Queensland, 1902.—Mr. Herbert E. Bellamy, C.E., has sent the following particulars as to the temperature and rainfall which he recorded at Rockhampton, Queensland, during 1902.

Rockhampton, the capital of Central Queensland, is situated in 23° 39′ S. lat. and 150° 30′ E. long. It is on the south bank of the Fitzroy River, about 33 miles from its mouth by course of river, and the greater portion of the city has an elevation of from 24 to 36 ft. above mean sea-level.

It might be mentioned that the rainfall in 1902 was the lowest on record for the past 32 years, the average annual amount for this period being 40·87 ins.

1902	Temperature. Extremes. Highest.	Lowest.	Means. Max.	Min.	Mean.	Rainfall. Total.	Greatest Fall in one day.	No. of Rainy Days.
	°	°	°	°	°	in.	in.	
January	104	67	95	74	84·5	4·79	1·59	8
February	100	69	93	73	83·0	1·36	1·00	3
March	98	64	90	69	79·5	1·68	1·50	5
April	92	48	83	61	72·0	·21	·12	6
May	99	45	81	57	69·0	...	...	0
June	84	40	78	52	65·0	...	...	0
July	80	37	76	49	62·5	·01	·01	1
August	90	36	74	52	63·0	·09	·09	1
September	90	51	83	58	70·5	1·41	1·39	2
October	98	59	88	65	76·5	·05	·05	1
November	99	61	86	66	76·0	·51	·41	2
December	105	61	94	69	81·5	5·69	1·41	11
Year	105	36	85·1	62·1	73·6	15·80	1·59	40

Remarkable Meteorological Phenomena in Australia.—On Wednesday, November 13, 1902, we experienced here in Australia some most extraordinary meteorological phenomena. For the previous five or six days, exceedingly hot, dry weather had prevailed, owing to winds blowing from the Australian interior, where a huge anticyclone was resting, in a coastward direction, the winds taking in Queensland and New South Wales a Westerly, and in Victoria a Northerly, direction. The hot weather culminated in terrific dust-storms in Queensland, New South Wales, Victoria, and South Australia, and during these storms "fire-balls" were seen hovering in the air. On the sea "red rain" was experienced by several passing vessels.

The following is an abstract of what happened :—

Melbourne, Wednesday, November 13.—Weather phenomenal, great heat, dust-storms, in all parts of Victoria.

At Boort, great fireballs fell in the street, throwing up sparks as they exploded. The whole air appeared to be on fire ; intervals of complete darkness ; lanterns had to be used in daytime, and fowls went to roost.

At Longdale, a house set on fire by a fireball.

Balls of fire burst on the poppet heads of the New Barambogie mine, Chiltern, Victoria, putting the timbering of the shaft on fire. Almost every meteorological station in Victoria sent in similar reports—fireballs, darkness in daytime, and people stumbling about with lanterns.

Sydney.—On November 14, Mr. Bruggman, of Parramatta, was paralysed by a fireball bursting over his head.

Harden, Wednesday, November 13.—During a storm yesterday at Murrumburrah, a huge "fireball" hovered over the houses for a considerable time, and then disappeared.—H. I. Jensen, Caboolture, Queensland, January 1, 1903—*Nature.*

THE EARLIEST TELEGRAPHIC DAILY METEOROLOGICAL REPORTS AND WEATHER MAPS.

By WILLIAM MARRIOTT, F.R.Met.Soc.

In the *Meteorological Magazine* for September 1896 Mr. Symons gave a photographic reproduction of the first "Daily Weather Map" ever published, being that for 9 a.m., August 8, 1851. In subsequent Nos., April and October 1897, he mentioned that in 1848 or 1849 Mr. J. Glaisher was commissioned by the proprietors of the *Daily News* to organise a number of stations for the purpose of a daily Meteorological Table which they wished to publish in that newspaper.

When preparing the obituary notice of Mr. Glaisher, I communicated with the manager of the *Daily News*, and asked him if he could give me any particulars respecting Mr. Glaisher's connection with that paper. He was not able to do so, but accorded me permission to examine the file of the paper. This I have done, and have confirmed most of the points mentioned by Mr. Symons; but I have also been able to carry the matter further back, and have discovered what I believe to be the first telegraphic Daily Weather Report. This appeared in the *Daily News* for Thursday, August 31, 1848, and shows the conditions prevailing on the previous day, viz. Wednesday, August 30. The Table is reproduced herewith:—

STATE OF THE WIND AND WEATHER.

[The state of the weather for the next two months must have such important consequences that we have made arrangements with the Electric Telegraph Company for a daily report.]

AT NINE O'CLOCK YESTERDAY MORNING the wind and weather at the undermentioned places were as follows:

Chelmsford	W	Fine	Manchester	SE	Cloudy
Colchester	WSW	Fine	Masborough	W	Fine
Derby	NE by N	Fine	Newcastle	SSW	Fine
Gloucester	ESE	Fine	Newmarket	W	Fine
Glasgow	SW	Fine	Norwich	W	Very fine
Gosport	WNW	Fine	Normanton	SW by S	Very fine
Hertford	N	Fine	Nottingham	W	Fine
Hull	WSW	Fine	Peterborough	NE	Fine
Leeds	W	Fine	Poole	W	Fine
Leicester	W	Fine	Portsmouth	WNW	Fine
Leith	W	Fine	Rugby	S	Very fine
Lincoln	S	Fine	Southampton	NW	Fine
Liverpool	NW	Fine	Yarmouth	W	Fine
London	W	Fine	York	NW	Fine
Lowestoffe	W	Cloudy			

Similar reports appeared daily for two months until October 30, and were then discontinued. These reports were much appreciated, and regret at their discontinuance was expressed by many persons, among whom was the Astronomer Royal. The proprietors of the *Daily News* were very gratified at the favourable reception of these weather reports, and they took steps early in the next year not only to continue the publication of the weather reports, but also to secure reliable and synchronous observations.

The matter was fully set forth in a leading article on March 17, 1849. This is so interesting as showing the public spirit of the proprietors of the *Daily News*, and how they were the pioneers of our present telegraphic weather information, that it seems desirable to give the article in full:—

The rainy and inclement weather which prevailed throughout last summer excited a considerable amount of anxious anticipation as the harvest approached. With a view to contribute as much as lay in our power to disperse or allay the fears of the general public, and at the same time to supply agriculturists with important practical information, we made arrangements for receiving and publishing daily, during the weeks when harvest operations were in progress, reports of observations on the state of the weather at a number of stations distributed over great part of England, made each at the same hour, and transmitted by electric telegraph. The eagerness with which these reports were looked to confirmed us in the opinion that we had hereby rendered a welcome service to the public. Though their importance ceased with the completion of the harvest, their utility for the instruction and guidance of agriculturists in conducting field operations remained almost entirely undiminished. It was therefore our purpose to have continued them, but difficulties were found to interpose in the way of ensuring that the observations made should be exactly simultaneous, and performed with the same scrupulous accuracy, and also in the way of their due transmission, which compelled us to desist from the attempt.

Some time after the termination of these reports, we received, in addition to various other representations, a communication from the Astronomer Royal requesting us to acquaint him (for his private information) whether their publication was finally discontinued. He assigned as the reason for inquiring his conviction that such a continuous statement of simultaneous observations of the wind in particular was likely to lead to results of great scientific value; and added that he had made preparations (large in reference to the nature of the subject) for laying them down graphically, and had been on the point of writing to us to suggest an extension of the list of places, so as to include some on the southern and western railways. It had been with regret that we relinquished the idea of continuing our reports, and this application stimulated us to a more determined attempt to obviate the difficulties which obstructed its realisation.

We opened without loss of time communications on the subject with the directors of the leading railway companies, and were gratified by meeting with prompt and liberal expressions of a desire to promote our views from the Directors of the Great Northern, the Great Western, the South-Western, the South-Eastern, the South Coast, the Lancaster and Carlisle, and the York, Newcastle, and Berwick Railways. We mention the names of those companies from whom we have received the first promise of co-operation, in part as an expression of our gratitude, in part as a tribute due to the promptitude of their compliance, indicative at once of a liberal wish to concur in operations of general utility, and a high-minded appreciation of the importance of scientific investigations. We have no doubt that equal liberality and intelligence will be found to animate their railway contemporaries when they find time to estimate the resources they have in their power to aid us; and even should we be mistaken on this point, the examples we have noticed may stimulate emulation.

Encouraged by the response we have met with, we have resolved to commence operations on as extensive a scale as is actually in our power, hoping with time to be able to expand and complete them. Our arrangements are so far advanced that we look forward with confidence to be able, in the course of a month, to begin the publication of daily meteorological reports from the following places: Reading, Swindon, Oxford, Bristol, Bridgewater, Exeter, Plymouth, Leighton, Rugby, Birmingham, Tamworth, Crewe, Liverpool, Manchester, Lancaster, Shap, Carlisle, Moffat, Lanark, Edinburgh, Glasgow, Peterborough, York, Leeds, Whitby, Darlington, Hartlepool, Newcastle, Sunderland, Berwick, Basingstoke, Southampton, Portsmouth, Hastings, Brighton,

Poole, Tunbridge, Folkestone. To these we shall hope to add—Gloucester, Conway, Holyhead, Kingston, Limerick, Galway, Dundee, Blackburn, Rochdale, Halifax, Sheffield, Colchester, Cambridge, Yarmouth, Lynn.

In selecting these places, we have been decided by various considerations, in some measure suggested by the Astronomer Royal, by whom also the choice of individual stations has been partly made. In the first place, it was of consequence that the extreme stations should be as far apart as possible. In plain countries it was not necessary to take places near each other, for there the variation from place to place is small. But where high hills intervene, it was obviously desirable to approximate the stations as closely as possible, and to have them on both sides, as well as at different elevations, and wherever a point was marked by peculiar features. Seaports are, in general, eligible stations, because in them the inhabitants are accustomed to take notes of the weather, particularly of the direction of the wind; and so are railway stations, on account of their proximity to the lines of electric telegraph. Of course the extent of the field over which the obtaining of simultaneous observations is practicable is limited by the extent to which the development of the railway and telegraph system has attained.

It appears of consequence to bestow a few words on the arrangements we have adopted with a view to ensure the accuracy and regularity of our reports. To every station where co-operation has been promised us, a wind-card has been, or will be, forwarded. The Superintendent of the Magnetic and Meteorological Department at Greenwich will, if possible, visit all the stations to examine the apparatus of wind-vanes which they possess, to furnish suggestions respecting the management, and to assist in fixing the bearing-points. Forms to be filled up with the information required will be supplied to the parties at the stations entrusted with the making of the observations. We subjoin a copy of these forms as the most laconic way of stating the information we propose to give:—

RUGBY.

Nine o'clock a.m. the	day of	1849	[Fill in date.]
The wind is from	quarter		[Fill in merely with letters, either N.—N.E.—E.—S.E.—S.—S.W.—W., or N.W.]
blowing			[Use one of following terms: Calm—Gentle Breeze—Strong Breeze—Hard Wind—Storm—Heavy Gale.]
The weather is			[Use one of following words: Cloudless—Partially Cloudy—Overcast—Foggy—Scud—Rain—Heavy Rain—Snow—Hail—Thunderstorm.]

Signature,

The observations are to be made daily at 9 a.m., and the adoption of London time at all the railway stations will ensure the complete simultaneity of these observations.

It is scarcely necessary to point out the scientific importance of such reports. Though much has been done of late years to throw light upon the theory of the laws which regulate storms and atmospheric phenomena in general, much remains to be done. Extensive and continuous local observations,

systematically pursued, are required in a great number of countries to complete the observations of striking atmospheric phenomena, extending over considerable portions of the globe, which have been published. If our attempt succeed, as we have no doubt it will, the example will, we are sure, be followed in Belgium, America, and other countries, where the combination of the railway and electric telegraph, and the development of the daily press, afford similar facilities to the undertaking to those which exist in this country. Our success will, in fact, redound to the honour of the railway and the press, as showing that they are capable of contributing with unprecedented power to the expansion of knowledge, as well as to the increase of the material wealth of society; and that their conductors are capable of aspiring to this nobler kind of usefulness. The results of the knowledge which must thus be acquired will possess a high practical utility as well as philosophical interest, for it is impossible to conjecture beforehand the extent to which navigation, horticulture, agriculture, and even mechanical processes of manufacture, may be benefited by juster views and more extended knowledge of meteorological science.

The first Table of these new synchronous Meteorological Observations was published in the *Daily News* on June 14, 1849, and showed the state of the weather on the previous morning (June 13).

The Table was as follows:—

METEOROLOGICAL TABLE,

Shewing the State of the Weather at each of the following places at Nine o'clock yesterday morning.

Name of Place.	Course of Wind.	Strength of Wind.	State of Weather.
Basingstoke	W.	Gentle Breeze	Partially Cloudy
Bridgewater	N.W.	Gentle Breeze	Cloudy
Brighton	N.	Gentle Breeze	Partially Cloudy
Bristol	N.W.	Gentle Breeze	Nearly Cloudless
Exeter	N.W.	Gentle Breeze	Partially Cloudy
Gloucester	N.E.	Gentle Breeze	Partially Cloudy
GREENWICH	N.E.	Gentle Breeze	Partially Cloudy
Oxford	N.W.	Calm	Cloudless
Plymouth	S.W.	Gentle Breeze	Partially Cloudy
Poole	N.	Gentle Breeze	Partially Cloudy
Reading	N.W.	Gentle Breeze	Partially Cloudy
Southampton	N.E.	Calm	Partially Cloudy
Swindon	N.	Gentle Breeze	Partially Cloudy

As explained elsewhere, the very extensive arrangements necessary for making this table complete have not yet been concluded. In a short time we shall present daily returns in addition to those above given, from Berwick, Birmingham, Blackburne, Cambridge, Carlisle, Colchester, Conway, Crewe, Darlington, Dundee, Edinburgh, Folkestone, Galway, Halifax, Hartlepool, Hastings, Holyhead, Kingston, Lanark, Lancaster, Leeds, Leighton, Limerick, Liverpool, Manchester, Moffat, Newcastle, Peterborough, Portsmouth, Rochdale, Rugby, Shap, Sheffield, Sunderland, Tamworth, Tunbridge, Whitby, and York.

I have communicated with Mr. W. H. M. Christie, F.R.S., the Astronomer-Royal, and asked him if he could favour me with any further information about the wind maps from the Royal Observatory records. He has kindly sent me the following Report, prepared by Mr. W. C. Nash, the Assistant in charge of the Meteorological Department:—

The scheme for graphically exhibiting the daily direction of the wind in the *Daily News* originated in a letter from the Astronomer-Royal, Sir George

(then Mr.) Airy, to the editor of that journal, dated November 6, 1848. In that letter the Astronomer-Royal asks whether the report of winds in the *Daily News* is finally discontinued, and proceeds: "This statement of simultaneous observations of the wind appeared to me likely to lead to results of considerable scientific value; and I had made preparations (large in reference to the nature of the subject) for laying them down graphically; and was on the point of writing to you to ask whether the list of places could not be extended to include some of those on the Southern and Western Railways. Perhaps you would have the kindness to acquaint me with your probable arrangements in this matter." No immediate action appears to have been taken, and on February 1, 1849, the Astronomer-Royal submitted to the *Daily News* a list of about 50 stations from which it seemed to him to be desirable that returns should be received. This list was adopted by the *Daily News* in a leading article in its issue of March 17, 1849, in which was also given a long extract from the Astronomer-Royal's first letter of November 6, 1848. Matters having thus been put into train, by arrangement with the *Daily News*, Mr. Glaisher was sent by the Astronomer-Royal, in April 1849, on a vane-verifying expedition, which extended throughout the country, and lasted several months.

The first reference to the maps is contained in an application from Mr. Glaisher to the Astronomer-Royal, dated July 18, 1849, "for one of the skeleton maps he purposed using for the discussion of the *Daily News* meteorological returns." There is no record, however, of the publication of these maps, but that they were being made daily is evidenced by the following extract from a letter from the Astronomer-Royal to Dr. Lloyd, dated April 23, 1850. "Some time ago the *Daily News* began, I know not on whose proposal, to give a daily return of the wind and weather at several stations. When they left off I wrote to them, and encouraged them to go on again; and we have now the return of the direction of the wind, with some idea of the force, and of the state of the weather generally, at 9 o'clock every morning. I thought it best to confine myself to simple information as we can really use it; and Mr. Glaisher lays it down on a chart every day."

A copy of this skeleton map, with the index stations marked on it, is preserved in the Observatory papers; but no copies have been found of the daily wind maps.

The final reference to the maps is contained in the following note from the Astronomer-Royal to Mr. Glaisher, December 20, 1851:—"I should think that Mr. Glaisher's best course in regard to the Meteorological Map would be to draw a new one, which I could probably engrave for the Observatory, treating the affair from that time as an Observatory business. I am certain that the best plan for the wind observations generally will be to let them die away from the end of this year, but to bestow some pains on the reduction of all up to this time."

The new map was not procured, and the proposed reduction does not appear to have been made. W. C. NASH.

April 28, 1903.

The following article by Prof. Cleveland Abbe in the U.S. *Monthly Weather Review* for May 1897 is of exceptional interest, as it throws additional light upon the matter, and also shows what was being attempted in America in the way of telegraphic weather reports about the same time:—

WEATHER TELEGRAPHY IN ENGLAND AND AMERICA.

It is well known that the first weather maps for the United States, as compiled daily by means of telegraphic reports, were made by the Smithsonian

Institution. In 1843 Espy had been engaged by the United States Government as Meteorologist; he was assigned to duty, at first under the Surgeon-General of the Army, afterwards, to the Secretary of the Navy, and finally, 1848, under the Secretary of the Smithsonian. During the first years of his work he compiled many daily maps from the monthly returns of the meteorological observers scattered over the country, and he published a liberal selection in his four successive Meteorological Reports. In 1847 Professor Henry began to devote special attention to this subject, and during the subsequent years, in co-operation with Professor Espy, the Smithsonian system of observers was largely extended, special investigations were made, the telegraph offices were supplied with instruments and reports secured for the compilation of daily maps; the prediction of storms was definitely proposed as the ultimate object of the work in hand. The telegraphic reports seem to have begun in 1849, at least experimental maps were then made for July 19 and 20 for Professor Henry by Dr. A. Jones in New York, and sent to Washington as samples. Dr. Jones wished to have New York made the central collecting-point.

Simultaneously with the work of Espy and Henry, and their co-labourers, Redfield, Loomis, Coffin, and Guyot, a similar development was going on in England. The electric telegraph company (using Wheatstone's system) had been incorporated in England in 1846, and by 1851 it had erected about 2000 miles of wire. At the first great World's Fair[1] at the Crystal Palace, near London, in 1851, weather reports were received by telegraph from many points, and a daily weather map published by lithography, beginning with August 8, 1851. A facsimile of this map is reproduced in *Symons's Monthly Meteorological Magazine*, September 1896.

The last number of *Symons's Magazine* (April 1897) contains further interesting information with regard to similar work in 1849 and 1850. Just before receiving that number of this magazine, the present editor had discovered and copied the following interesting letter from Mr. James Glaisher, which has been fortunately preserved among the fragments of correspondence saved from the destruction of the records of the Smithsonian at the disastrous fire of January 1865. These records are now accessible to the student, and the letter here reprinted, taken in connection with the important and authoritative sketch published by Mr. Symons, shows that Mr. James Glaisher, the Nestor of meteorologists, who is still living at an advanced age in London, was, so far as we know, the first to organise a system of strictly simultaneous observations, and to compile the corresponding daily bulletins and weather maps. According to Mr. Symons, Glaisher's first map was that for June 14, 1849, or five weeks before that of Dr. Jones in New York. He does not appear to have utilised the expensive assistance of the electric telegraph, but by the co-operation of the railroad companies, and at the expense of the proprietors of the *Daily News*, he was able to gather together every night the meteorological observations made at 9 a.m. (Greenwich time), and publish his *bulletin* in the next morning's paper. The *map* was not published, but was compiled and studied by himself individually. The similar work done in this country, the history of which has often been rehearsed, was evidently as little known to Glaisher as was his own work in America. It is but another and a most striking illustration of the simultaneous origin of many of the important discoveries and inventions that mark the progress of the human race throughout the world.

Regretting that we are not able to print the letter written by Professor Henry on June 5, we think ourselves fortunate in submitting the following reply by Mr. Glaisher.

[1] This was the Great Exhibition in Hyde Park in 1851.—W. M.

[Before quoting Mr. Glaisher's letter it will be best, in order to make the history as complete as possible, to give the following extract from the minutes of the Council Meeting of this Society held on July 2, 1850:—

The following letter was read from Joseph Henry, the Secretary of the Smithsonian Institution at Washington, addressed to James Glaisher, Esq., Secretary of the British Meteorological Society:—

"The Smithsonian Institution is attempting to establish a system of Meteorological observations to be extended as far as possible over North America, and I now address you for the purpose of requesting that you will furnish us with a copy of the forms you have adopted in your system of observations, and favour us with any suggestions which may be the result of your experience.

"The portion of the income of the Institution which can be devoted to Meteorology is too small to enable us to do more at present than make a beginning, and to gradually extend the system. We hope, however, to collect considerable information of importance with regard to the movement of the air, and to the extent and direction of the storms of this country.—I have the honour to be, very respectfully, your obedient Servant,

JOSEPH HENRY, *Secretary*,
Smithsonian Institution.

"James Glaisher, Esq., F.R.S."

It was then moved by Dr. Lee, and seconded by Mr. Drew, that the Secretary be desired to send copies of all papers which this Society may publish, etc., to the Secretary of the Smithsonian Institution.

This motion passed unanimously.

Mr. Glaisher's letter was as follows:—]

13 DARTMOUTH TERRACE, BLACKHEATH, KENT,
July 8, 1850.

MY DEAR SIR—In reply to your letter of June 5, I beg to say that I shall have great pleasure in sending you copies of the forms I use in collecting Meteorological observations, and the results of my experience are entirely at your service. In your letter you have not indicated the channel through which you wish the papers to be sent, and therefore I shall forward them through the Royal Society.

With the papers I shall send you will find a few copies of an Address of a new Society, which myself with a few gentlemen have formed. It is under the presidency of S. C. Whitbread, Esq.

At the meeting of the Council of this Society, held a few days since, I did myself the pleasure of reading the letter with which you have favoured me, and it was resolved that a form for collecting observations, drawn up by myself, and now in the printer's hands, should be sent to you, and the Council expressed a wish to co-operate with the Smithsonian Institution as far as possible. Hitherto, there has been no fund devoted to Meteorology in England, and I have borne all the expenses, excepting that each gentleman has furnished himself with his instruments; Government, however, has published the results in the reports of the Registrar-General, some of which I send.

We hope now to collect much more information than I have hitherto done, and if the system adopted by you be similar to that adopted by us, their united results will be more valuable.

Among the forms sent you will find one very simple, and which is used daily at about 50 different railway stations at the hour of 9 a.m., Greenwich time. The different railway companies have agreed that the stationmasters shall take these observations, and that they shall be brought to London the same day, free of expense. The proprietors of a London newspaper, the *Daily News*, incur the expense of sending a messenger to the several railway termini at about 2 a.m., and all the returns thus collected are immediately printed, so that the weather of the day previous, at one time, all over the country and parts of Scotland are publicly known. On receiving the paper, I lay all these returns on a map, using a long narrow-headed arrow to indicate the direction of the wind, and other symbols for the other information, and thus daily I know the weather, direction of the wind, etc., the whole being exhibited to the eye. Several gentlemen, whose names you will see in a form headed "simultaneous observations taken at 9 a.m.," have agreed to co-operate with me, and to take all the observations taken by the railway stationmasters, as well as others, with their full sets of instruments. It is believed by these arrangements that very important information, with respect to the passage of storms in particular, will thus be collected. I have already more than one year's observations and daily maps in an unbroken series.

Previous to commencing these observations, I visited every station, determined its meridian, fixed a compass card, and instructed the stationmaster, remaining with him till I felt certain he would take the observations well.

The method I have adopted with respect to the observations of general phenomena is first to superintend the making of the instruments, then their selection. I determine their index errors by carefully examining and comparing every instrument with a standard. I visit the different locations in which they are placed and examine the position of the instruments themselves.

On receiving the returns, I first examine every one by itself; second, I divide them into groups, including the observations from one known good observer, and then I compare every result in every return with the corresponding result in the standard return, taking into account difference of elevation, etc.; next, I form groups according to latitude, and another according to the longitude; by these means I usually detect any errors, and I believe very few escape. After this I proceed to their combinations, etc.

In future the British Meteorological Society intends having monthly returns, including every observation, and for which a form is now being set up; I shall, therefore, be more certain of the accuracy of the results.

I should be glad to have some arrangements made with the captains of steam-vessels between America and England, thus connecting the observations taken in both countries, and I think this may ultimately be done.

I have the honour to be, Sir, with much respect and esteem, yours very truly,

JAMES GLAISHER.

The above letter by Mr. Glaisher is peculiarly interesting, as it not only gives an account of what was being done in this country to organise systematic meteorological observations, but it is also the first official communication from the Council of this Society.

The concluding paragraph has to-day a special significance when it has just become possible to receive by Marconigrams instantaneous information regarding the weather from ships in mid ocean.

It may perhaps be of interest to give the following brief chronological statement with reference to the Daily Meteorological Reports and Weather Maps in the British Isles:—

1848, August 31.—Publication in the *Daily News* of the first telegraphic Daily Weather Report.

1849, June 14.—Publication in the *Daily News* of the first synchronous Meteorological Observations.

1849, July.—Preparation of MS. Daily Weather Maps by Mr. J. Glaisher under the direction of the Astronomer-Royal.

1851, August 8.—First printed Daily Weather Map issued at the Great Exhibition, Hyde Park.

1860, September 3.—First Government Daily Weather Report prepared by Admiral FitzRoy, and issued to the principal newspapers.

1861, February 5.—First Cautionary or Storm Warning Signals issued by Admiral FitzRoy.

1861, August.—Admiral FitzRoy's Forecasts of Weather first published.

1861, September 3.—Publication of Weather Map of the British Isles by the Daily Weather Map Company, Limited (see *Quarterly Journal of the Royal Meteorological Society*, vol. xxvii. p. 258).

1869, January 12.—Issue of the first lithographed Daily Weather Report by the Meteorological Office.

1871, January.—Publication by the *Shipping and Mercantile Gazette* of Daily Wind Charts of the British Isles.

1872, March 11.—First issue of the Daily Weather Maps by the Meteorological Office.

1875, April 1.—Publication by the *Times* of the 6 p.m. Weather Map.

Clear-Sky Thunderstorm.—In the meteorological log of the ss. *Moravian*, Capt. A. Simpson describes a thunderstorm experienced on December 30, 1902, just on getting within range of Cape Verde lighthouse, bearing north. At 1.30 a.m. a warm puff of dust-laden wind came off the African shore. Lightning, at first distant on the north-east horizon, became almost continuous, with loud thunder. All the stars were visible; only upper clouds, no cumulus, in the sky. Capt. Simpson had never before experienced a severe thunderstorm without cloud. For fully an hour the sky was one blaze of lightning, and the wire ropes, mast-heads, yard-arms, derrick ends, etc., were lighted up. All the stays seemed to have glow-lamps 3 to 4 feet apart, and the mast-heads and yard-arms a bright light at their extremities. The officers and passengers were roused to witness the weird spectacle.

The most remarkable part of the phenomenon was the extraordinary sound emitted throughout. It was exactly like the noise of the sparks from the carbons of an arc lamp; or as if several thousands of cicadas had taken up their quarters in the rigging; or the crackling of burning grass or twigs. This noise was not local near the bridge, but the officers reported it all over the ship, even in the neighbourhood of the noisy steering-gear. Wind steady, North-east to East-north-east, a gentle breeze. It was thought that heavy clouds would form or a violent tornado burst, but the disturbance was too high. The ozone in the atmosphere was very strong at times.

There are large numbers of records of corposants in the logs at the Meteorological Office, but it seems to be exceptionally rare for observers to detect the crackling sound mentioned above by Capt. Simpson. On June 1, 1888, in 13° S., 90° E., Capt. Hughes, ship *Candahar*, recorded "very vivid lightning, very heavy thunder; corposants on three mast-heads, and making quite a loud tick, similar to a large galvanic battery." In this case, however, the sky was completely overcast with nimbus and other lower cloud forms.—*Monthly Pilot Chart*, April 1903.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 21, 1903.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

WILLIAM READ BELL, M.Inst.C.E., Pretoria, Transvaal;
ARTHUR M. EDWARDS, Barncote, Reigate;
JOHN M'CONNELL, Lanzi, Campiglia Marittima, Italy;
WALTER EPHRAIM MARKHAM, 79 Essex Road, N.;
WILLIAM FREDERICK PREEDY, Spencer Road, Croydon;
WILLIAM PROWSE, M.R.C.S., St. Briavels, Salcombe;
Major VICTOR STAUNTON SANDEMAN, Whin-Hurst, Hayling Island; and
THOMAS THORNTON, 23 Egerton Gardens, S.W.,
were balloted for and duly elected Fellows of the Society.

January 21, 1903.

Annual General Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

Mr. F. B. EDMONDS and Mr. T. HENNELL were appointed Scrutineers of the Ballot for Officers and Council.

Mr. F. C. BAYARD read the Report of the Council and the Balance-Sheet for the year 1902. [This will appear in the next number of the *Quarterly Journal.*]

It was proposed by the PRESIDENT, seconded by Mr. F. C. BAYARD, and resolved: "That the Report of the Council be received and adopted, and printed in the *Quarterly Journal.*"

It was proposed by Mr. F. DRUCE, seconded by Mr. S. W. SILVER, and resolved: "That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year, and also to the Auditor."

It was proposed by Dr. W. N. SHAW, F.R.S., seconded by Mr. E. MAWLEY, and resolved: "That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its meetings in the rooms of the Institution."

The PRESIDENT then delivered an Address on "THE METHOD OF KITE-FLYING FROM A STEAM-VESSEL, AND METEOROLOGICAL OBSERVATIONS OBTAINED THEREBY OFF THE WEST COAST OF SCOTLAND" (p. 65).

It was proposed by Dr. H. R. MILL, seconded by Mr. H. MELLISH, and resolved: "That the thanks of the Society be given to Mr. W. H. DINES for his services as President, for his carrying out the Kite Observations, and for his Address, and that he be requested to allow the Address to be printed in the *Quarterly Journal.*

"That a copy of this Resolution be engrossed and presented to Mr Dines."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year:—

PRESIDENT.

Capt. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

VICE-PRESIDENTS.

WILLIAM HENRY DINES, B.A.
Capt. MELVILLE WILLIS CAMPBELL HEPWORTH, C.B., F.R.A.S.
EDWARD MAWLEY, F.R.H.S.
WILLIAM NAPIER SHAW, M.A., D.Sc., F.R.S.

TREASURER.

CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E., F.R.G.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., D.Sc., F.R.S.

COUNCIL.

RICHARD BENTLEY, F.L.S., F.R.G.S.
JOHN YOUNG BUCHANAN, M.A., F.R.S., F.R.S.E.
Capt. WARREN FREDERICK CABORNE, C.B., F.R.G.S., F.R.A.S.
Capt. ALFRED CARPENTER, R.N., D.S.O., F.Z.S.
RICHARD HENRY CURTIS.
FRANCIS DRUCE, M.A., F.R.G.S.
WILLIAM ELLIS, F.R.S., F.R.A.S.
CHARLES HAWKSLEY, M.Inst.C.E.
JOHN HOPKINSON, Assoc.Inst.C.E., F.R.M.S.
RICHARD INWARDS, F.R.A.S.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
HENRY MELLISH, J.P., F.R.G.S.

Mr. W. H. DINES having left the Chair, it was taken by Capt. D. WILSON-BARKER, the newly elected PRESIDENT, who thanked the Fellows for having elected him to that Office.

February 18, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

HARI DAS DAS, Raghunattiganj, North India ;
HENRY EDWARD GOLDSMITH, Hong Kong ;
WILLIAM GRIMBLE GROVES, J.P., Holehird, Windermere ;
KHAN BAHADUR ABDUL LATEEF SAIL, Bapatla, India ;
GEORGE OLIVER, M.D., Riversleigh, Farnham ; and
PERCIVAL HORTON SMITH, M.D., 19 Devonshire Street, W.,
were balloted for and duly elected Fellows of the Society.

The PRESIDENT stated that he had to announce with regret the death of Mr. JAMES GLAISHER, F.R.S., which occurred on February 7 (see p. 120).

The following communication was read :—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1902," by EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S. (p. 87).

CORRESPONDENCE AND NOTES.

Rain and Dust Fall in Edinburgh, 1902.—Dr. W. G. Black has forwarded the accompanying Table of Rain and Dust Fall in the Central District of Edinburgh for 1902, together with the Evaporation.

The fall of Dust and Soot in an open dish or gauge of 75 sq. ins. amounted to 2 oz., giving 3·8 oz. per sq. ft., or about 24 lbs. for 100 sq. ft., for the year 1902, an excess over that of 1901, or 3·8 oz. to 1·30 oz. which consisted mostly of sand blown from the building operations carried on at the University Union near by, and at the Girls' Schools in the Square. The appearance of sand in the dish seems to be an infallible indication of building work going on in the neighbourhood, and the ability of the wind to hold heavy particles suspended in it and carry them some distance to be deposited in sheltered places.

The Rainfall was much less than usual, 16·227 ins., only four-fifths of 1901 (21·464 ins.), owing to deficiencies in the autumn months and absence of equinoctial gales at that time; but the number of rainy days was increased to 179 from 140, occasioned by the 1902 rains consisting mostly of drizzle instead of heavy showers.

The Evaporation statement was characterised by an unusual deficiency in June, ·980 in., contrasted with that in June 1901, 2·005 ins., of a double amount, owing to the prevalence of cold weather for three weeks, which only changed to warm in the last week of the month. The total amounts were, however, nearly approximate, 14·508 ins. in 1901 and 13·540 ins. in 1902, which leads one to suppose that evaporation may not generally reciprocate with rainfall, either in increase or in decrease, but would coincide more with temperature of the air at the time.

Dust and Rainfall at George Square back garden, in the city of Edinburgh. Diameter of funnel, 6 ins. Rain-gauge—height of top above ground, 3 ft.; height of top above sea-level, 265 ft.:—

1902.	Rainfall.	Evaporation.	Soot and Dust.	Number of days on which Rain fell.	Snow fell.
	in.	in.	grs.		
January . .	·955	·655	33	17	5
February . .	·895	·585	25	13	3
March . .	·805	1·095	36½	20	1
April . .	1·190	1·115	160*	13	2
May . . .	2·190	1·705	49	19	3
June . . .	2·145	·980	29	18	...
July . . .	2·835	1·720	26	9	...
August . .	1·385	1·375	80	9	...
September . .	1·290	1·060	60	10	...
October . .	·795	1·430	120*	15	...
November . .	·408	1·120	109*	16	...
December . .	1·334	·700	140*	20	1
Total. . .	16·227	13·540	867½	179	15

* Sand.

Rapid Barometric Fluctuations.—It frequently, if not always, happens that when, in the winter months, Europe, or the greater part of it, is covered by an anticyclone of considerable intensity, with generally quiet, cold weather, the conditions over the upper portion of the Atlantic are of an exceedingly stormy character, gales being almost of daily occurrence, often severe, and attended by violent changes of pressure. December 1902 afforded a marked illustration of these features. During the earlier part of the month the region of highest pressure occupied the western half of Europe, the barometer attaining its maximum on the evening of the 5th, when 31·01 ins. was registered in the south of Sweden. On the transatlantic steamer routes very

disturbed weather was reported at this time. "We have had a stormy passage," wrote Capt. Lumsdane, ss. *Ethiopia*, "one gale hardly finished when another began." His worst experience was a North-westerly gale of hurricane force (12); others report a whole gale (10), or a storm (11). Northward of the 40th parallel and westward of about the 25th meridian the gales were accompanied by great and sudden changes of the barometer, many of the observations showing rises and falls of from 1 in. to more than 1¼ in. in 24 hours. In the case of the ss. *Manitou*, Capt. Cannons, the mercury dropped more than an inch between 8 p.m. 5th and 8 a.m. 6th, in about 46° N., 50° W. On the ss. *Ethiopia* the mercury travelled up and down a total of over 3 ins. in the 48 hours ending 8 a.m. 8th, in 50° N., 42° to 47° W.—*Monthly Pilot Chart*, March 1903.

Meteorology in the Transvaal.—We understand that Mr. Robert T. A. Innes, F.R.A.S., of the Royal Observatory, Cape of Good Hope, has been appointed Director of the newly formed Meteorological Department at Pretoria, Transvaal.

The Action of Lightning-Strokes on Buildings.—The Lightning Research Committee, organised by the Royal Institute of British Architects and the Surveyors' Institution, have issued a summary of records received from observers in 1902. That the cases reported are fewer than in the previous year is not owing to any falling off in the number of buildings affected by lightning-stroke; judging from the newspaper reports the average for the year seems to have been more than maintained. The reduced number recorded is due to the decision of the Committee to confine their investigations to "protected" buildings which have been damaged, in order to discover if possible the causes of failure of the systems of protection adopted. Hence observers were asked for reports of such cases only. With the exception, therefore, of records made before this limitation was decided upon, and of a few others which have been admitted because they contained features of special interest, the records summarised in this Report relate only to "protected" buildings. The Committee hope to be in a position to consider their Report at the end of the year; meanwhile they again tender their thanks to observers, and request their continued co-operation in this important work.

The following is an extract from the Report of the visit of the Honorary Secretary, Mr. Killingworth Hedges, M.Inst.C.E., to the United States and Canada, September-October 1902:—

"The general opinion was that, owing to the very inefficient protection which had been afforded in the past by the contractors who had installed lightning-rods on many public and private buildings, it was gradually dropped out of architects' specifications, and at the present time few new buildings are protected at all. Buildings are often struck, but as the insurance policy covers the loss, little notice is taken, although deaths occur either by direct stroke or from chimneys or masonry falling. I was informed that the present conditions were thought to be unsatisfactory, and that architects and engineers generally would like to be advised as to what protection they should adopt. That a large amount of damage by fire caused by lightning does take place is shown by the reports of the Fire Commissioners. The action of lightning when striking those high steel buildings known as sky-scrapers is peculiar and is worth investigation, as examination does not show in what direction the current flows to earth. In many cases in New York the buildings are insulated from the ground, by the fact that the foundation is blasted out of the rock which forms the island on which the city is built."

Climate of Merzifoun, Asia Minor.—Mr. J. J. Manisadjian has favoured us with the accompanying records of temperature and rainfall at Anatolia

College, Merzifoun, in Asiatic Turkey. The lat. is 40° 51′ N., and the long. 35° 31′ E., the height above sea-level being 2464 ft. The temperature observations are taken at 7.15 a.m., 1.45 and 9 p.m., and the means have been worked out by the following formula, viz. $\frac{7·15+1·45+9+9}{4}$.

Temperature 1893-1902.

Month.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
	°	°	°	°	°	°	°	°	°	°
January . .	35·8	32·9	43·7	33·0	38·7	20·3	30·4	38·3	31·1	31·3
February . .	30·0	32·4	43·5	32·9	38·7	37·9	36·0	42·3	40·7	41·4
March . .	40·4	41·7	43·8	42·1	46·7	41·9	41·8	39·1	49·6	41·4
April. . .	41·0	52·1	51·2	48·7	56·4	52·4	52·6	51·8	53·1	49·8
May . . .	61·2	64·0	56·5	59·9	66·4	56·3	62·3	59·0	56·7	59·0
June . . .	67·2	68·5	66·5	68·5	74·1	62·4	62·6	64·0	68·9	65·3
July . . .	73·4	71·4	74·3	73·0	77·0	70·7	67·5	69·8	70·7	64·8
August . .	71·2	71·6	73·2	76·1	74·5	68·2	68·9	69·2	71·3	68·4
September. .	63·3	63·1	61·3	68·7	70·5	61·5	68·0	58·2	61·9	58·8
October . .	58·5	62·4	60·4	63·3	58·8	58·0	51·8	56·1	52·9	52·9
November. .	52·3	44·0	48·7	48·0	37·8	44·0	39·6	42·0	42·6	37·1
December . .	39·4	38·2	41·4	40·7	35·8	33·3	33·1	39·7	40·8	33·4
Year . . .	52·8	53·5	55·4	54·6	56·3	50·6	51·2	52·5	53·4	50·3

The warmest year during the period was 1897, and the coldest year 1902. The warmest month was July 1897, with a temperature of 77°·0 ; and the coldest month was January 1898, with a temperature of 20°·3. The highest day temperature was 99°·5 on August 6, 1895, and the lowest – 2°·2 on February 10, 1893.

Rainfall 1896-1902.

Month.	1896. Rain.	1896. Rainy Days.	1897. Rain.	1897. Rainy Days.	1898. Rain.	1898. Rainy Days.	1899. Rain.	1899. Rainy Days.	1900. Rain.	1900. Rainy Days.	1901. Rain.	1901. Rainy Days.	1902. Rain.	1902. Rainy Days.
	in.		in.		in.		in.		in.		in.		in.	
January .	·40	6	·95	3	1·26	12	·52	4	1·65	11	·37	4	1·08	8
February .	·15	3	1·05	7	·95	9	2·30	11	·61	6	1·77	7	·84	9
March . .	1·22	4	·96	7	·73	4	1·46	8	3·89	11	2·06	7	4·00	7
April . .	1·47	5	2·22	12	1·27	10	4·32	14	2·44	8	2·72	8	1·59	7
May . . .	3·69	17	3·59	19	3·24	17	1·29	2	3·51	11	2·02	12	1·42	6
June . .	2·78	10	2·79	11	3·24	12	3·13	11	2·47	10	2·71	7	·66	5
July . . .	1·27	3	·12	3	·02	1	1·00	6	·19	1	1·91	7	·94	3
August . .	·40	1	·67	2	...	0	1·83	3	·72	3	1·89	3	·45	1
September .	2·35	5	·95	2	·96	3	·46	2	...	0	2·14	6	·54	2
October. .	·34	2	1·15	7	2·95	5	1·81	11	·59	2	·64	4	·56	3
November .	1·85	4	·50	5	·65	3	2·15	7	·32	3	2·67	10	2·15	9
December .	·76	6	1·25	8	1·27	7	·68	4	2·04	6	2·79	6	2·60	7
Year . .	16·68	66	16·20	86	16·54	83	20·95	83	18·43	72	23·69	81	16·83	67

The heaviest rainfall was 1·65 in. in 3 hours on August 15, 1899, but one heavier in relation to time was ·55 in. in 20 minutes on May 26, 1898.

The "Scotia's" Voyage to the Falkland Islands.—In the *Scottish Geographical Magazine* for April there is an interesting account of the voyage of the *Scotia*, the ship conveying the Scottish National Antarctic Expedition. The vessel left Kingstown on November 8, 1902, and arrived at Stanley Harbour, Falkland Islands, on January 6, 1903.

The following notes by Mr. R. C. Mossman will show what he is doing in the way of taking meteorological observations:—

"The exposure of meteorological instruments on board ship is associated with many difficulties which do not present themselves at land stations. This applies more particularly to thermometric observations, which are liable to be

vitiated by heat from the engines, and air currents from the galley and cabins of the vessel. On the *Scotia*, special attention has been given to this matter in order that the best possible results may be obtained, duplicate methods of observation being employed in many cases. The form of thermometer screen adopted is the small single-louvred pattern recommended and supplied by the Meteorological Council, who have, by the loan of instruments and in other ways, rendered valuable help to the expedition. Two of the screens above referred to are in use, each containing a dry and wet bulb thermometer. They are secured to ports which project clear of the ship's side to the extent of eighteen inches. One is placed on the starboard and the other on the port side, well aft on the poop. Both boxes are read at each observation, and the indications of the instruments exposed on the weather side are entered as giving the closest approximation to the true thermal condition of the surrounding atmosphere. A further check is afforded by the records of three Richard thermographs, which give continuous records of temperature on charts coiled around brass cylinders actuated by a clock movement. Some little trouble was at first experienced with the wet-bulb thermometers. This was found to be due to saline accretions on the muslin and bulb of the instrument, such as are formed on every exposed part of a vessel at sea. The result was that in the course of a week or so a coating of salt formed round the bulb which could with difficulty be removed by scraping with a knife, or even dissolved by placing the thermometer in *tepid* water. By changing the water in the reservoir frequently, and placing a fresh piece of muslin on about once a week, thoroughly satisfactory results were obtained, the wet bulb being further syringed daily with distilled water. A Richard hair hygrograph was employed as a check, so that any serious discrepancy between the two instruments was at once apparent. For the measurement of the intensity of solar radiation a black-bulb thermometer *in vacuo* was employed. This was fixed in a stand secured to the bridge in such a position that the sun could shine on it as nearly as possible at all hours of the day.

"Two barometers of the new marine pattern are in use; one being placed in the deck laboratory at a height of seven feet above the sea, while the other is a spare instrument, and is kept aft in the cabin. Three self-recording Richard barographs yield continuous traces of barometric pressure. One of Dr. Black's marine rain-gauges is placed aft on the poop, well clear of the deck. Its position is changed occasionally as circumstances arise, in order that it may always be on the weather side. The exposure—taking into account the various difficulties attending rainfall observations at sea—is a very good one, as the gauge is never sheltered by the sails. The thickness of the rainband in the spectrum of sunlight is taken daily at noon, and the temperature of the sea-surface is observed every four hours, and at frequent intervals when rapid changes are in progress. For ascertaining the height of ocean waves a Richard statoscope is employed. This is really an extremely delicate aneroid barometer, in which changes of pressure are magnified twenty-five times. A chart, actuated by clockwork, receives a trace of the pressure fluctuations due to the rise and fall of the waves, the height of which can thus be readily determined. Aft, on the poop, is a small machine for reeling in the piano wire attached to box-shaped kites of the Blue Hill pattern. Specially constructed meteorographs made of aluminium are carried up by the kites, and a record of the vertical distribution of pressure, temperature, and humidity is thus graphically recorded. The expedition is well equipped with sunshine recorders and other special instruments for use in high latitudes at the winter station which is to be established. Observations four times daily were commenced immediately after leaving Kingstown; but on reaching lat. 30° S. hourly observations were initiated, and these will be continued until the termination of the expedition.

"The results of these observations, taken by night as well as by day, should form an interesting contribution to Antarctic meteorology, especially as regards the diurnal range of the climatic elements over an ice surface.

"The weather during the voyage to the Falklands was fine and dry, rain falling on only fifteen days, the total recorded being 2·87 ins. Of this quantity practically half fell in one or two heavy showers on December 7 and 8, about lat. 3° to 6° N. It was interesting to note the regularity of the diurnal range of barometric pressure in tropical and sub-tropical regions. Between the parallels of 15° N. and 30° S. the temperature was high and equable, ranging from 75° to 82°; the relative humidity was comparatively high, and the thickness of the rainband a marked feature in spite of the small precipitation. A rapid fall of temperature took place on December 29, when in lat. 35° S. and long. 50° W.; and on this day and the one following a moderate gale blew from the South, accompanied by a low relative humidity. Lightning was frequently observed, and was essentially a nocturnal phenomenon. Only one thunderstorm was noted, viz. on January 4, when in lat. 47° S. long. 57° W. The green flash was seen on two occasions, being specially marked at sunset on December 18. The earth shadow was also noted on several occasions, and shooting-stars were unusually numerous from December 18 to 21."

RECENT PUBLICATIONS.

Abrégé des Instructions Météorologiques. Par ALFRED ANGOT, Météorologiste Titulaire au Bureau Central Météorologique de France. Paris, 1902. 8vo. viii. + 43 pp.

This pamphlet contains brief instructions to meteorological observers in France in the use of instruments and in the methods of observing in order to secure uniformity.

Annales de l'Observatoire Physique Central Nicolas. Publiées par M. RYKATCHEW, Directeur. Année 1900. I. et II. Partie. St. Petersburg, 1902. 4to.

These two volumes, which together make up 1503 pages, contain the meteorological and magnetic observations at several observatories, the principal of which are Pavlovsk, St. Petersburg, Ekaterinburg, and Irkoutsk; the rainfall results from 2439 stations; the second order observations made 3 times a day at 87 stations; and the monthly and annual results from 737 stations in the Russian empire.

Instructions to Observers of the India Meteorological Department. By J. ELIOT, M.A., F.R.S., F.R.Met.Soc., C.I.E., Meteorological Reporter to the Government of India, and Director-General of Indian Observatories. Second Edition. 8vo. Calcutta, 1902. iv. + 120 pp. and 3 plates.

The present book of instructions for meteorological observers in India is intended to supersede the *Indian Meteorologist's Vade Mecum*, which is no longer in print. Since the publication of that work in 1877, a large number of changes have been made in the methods of taking and recording observations in India, which have made it necessary to prepare a new book of instructions for observers.

Meteorological observers in India now merely take the readings of certain meteorological instruments and forward by telegram or by post on suitable

forms the statements of these recorded readings or observations to the Indian Meteorological Office. The reduction and preparation of the data for subsequent use and discussion is done in one or other of the meteorological offices in India. This pamphlet of *Instructions to Observers* is therefore confined to a description of the various instruments in use at the meteorological observatories in India, the precautions to be taken to maintain them in good order, the methods to be used to restore them to good order when it is possible for the observer to do it, and the proper methods of reading the instruments and of taking and recording the observations. No explanations are given as to how the readings are corrected and reduced for inclusion in the *Daily Weather Reports* and other publications of the Department. It is simply a book of instructions to enable Indian observers to take and record the observations of the meteorological instruments entrusted to their care satisfactorily and correctly.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. December 1902—February 1903.

The principal articles are:—"Ueber die Aenderungen des Grundwasserstandes nach den vom Prälaten Gregor Mendel in den Jahren 1865-1880 in Brünn ausgeführten Messungen": von J. Liznar (7 pp.). It is rare to find a Bishop who has been a Professor of Physics, and Bishop Mendel has given the results of his work in honour of the 50th anniversary of the founding of the School at Brünn. Dr. Liznar gives an abstract of the work. Special attention is given to the variations in level of the ground water.

"Das Klima von Deutsch-Ostafrika": von H. Maurer (6 pp.). It is interesting to receive information as to the climate of Africa, and Dr. Maurer has given a lecture on the subject at the German Colonial Congress in Berlin.

"Verhalten der Rheintemperaturen in den Jahren 1895-1900": von A. Stolberg (4 pp.). This is an interesting comparison between these results and those of Förster in Penck's *Geographical Abhandlungen*, 1894.

"Zum Klima des Staates Ceará, Brasilien": von Prof. F. M. Draenert (8 pp.). This is another interesting paper on the climate of South America.

"Die meteorologischen Verhältnisse auf der Bjelašnica (2067 m.) in Bosnien": von J. Hann (19 pp.). This is a careful discussion of the results from this peak, which is the only mountain station in the Balkans. This station is particularly stormy in winter, but has more fine, sunny days than the Alpine mountain stations. Great credit is due to M. Ballif, the head of the Bosnian meteorological system, who has succeeded in erecting and maintaining the station at this level.

"Arthur Schuster über Methoden der Forschung in der Meteorologie" (12 pp.). This is a reproduction of the paper in *Nature* for October 16, 1902.

"Probleme des Wärmehaushaltes des Erdballs": von Alex. Woeikof (5 pp.). This is an interesting discussion of the question whether the water surface of the sea, and especially of great lakes, has a greater influence than land surface on the exchange of temperature with the atmosphere.

"Die Resultate der Karaboghaz-Expedition": von A. Woeikof (4 pp.). This is an account of soundings on the eastern side of the Caspian.

"Die Isothermen im westlichen tropischen Südamerika": von A. Woeikof (2 pp.). This is a short note on the conditions of climate of Peru and Ecuador.

"Die Frühlingsankunft der Wandervögel und die Witterung in Ungarn": von J. Hegyfoky (7 pp.). This is an interesting phenological paper.

"Der Wolkenbruch vom September 1902 in Sizilien und die Überschwemmung von Modica": von Prof. G. T. Grimaldi (4 pp.). This is an account of the floods of last September in Sicily.

Rainfall of India. Eleventh Year, 1901. *Published by the various Provincial Governments and Issued under the authority of the Government of India by the Meteorological Department.* Calcutta, 1902. Folio.

This portly volume (3 inches thick) is a collection of the monthly statements of rainfall published by the various Local Governments, and gives practically the whole of the available rainfall data for the year 1901 of the Indian Empire.

The daily records are given *in extenso.* Although the rainfall is measured to hundredths of an inch, a "rainy day" in India is assumed to be that on which a tenth of an inch or upwards has fallen, and not a hundredth of an inch as in this country; the total number of rainy days is therefore calculated on that supposition.

Rapport sur les Observations Internationales des Nuages au Comité International Météorologique. Par H. HILDEBRAND HILDEBRANDSSON. I. *Historique, Circulation Générale de l'Atmosphère.* 8vo. Upsala, 1903. 48 pp. and 22 plates.

This Report gives a very interesting summary of the results hitherto obtained at various stations, with a full account of the several persons responsible for the observations, and of the length of time for which the observations were continued.

Prof. Hildebrandsson's conclusions are as follows:—

1. Above the thermal equator and the "equatorial calms" there exists during the whole year a current from the East which appears to possess a great velocity at high altitudes.

2. Above the Trade Winds there is a Return Trade, from South-west in the Northern and from North-west in the Southern Hemisphere.

3. This Return Trade does not pass beyond the northern limits of the Trade. It is diverted more and more to the right in the Northern and to the left in the Southern Hemisphere, so that it is converted into a Westerly current above the crest of the barometrical maximum of the tropics, and it descends and reinforces the Trade Winds.

4. The regions situated on the equatorial edge of the Trade are included in the Trade or in the equatorial calms, according to the season.

5. The barometrical pressure diminishes gradually from the tropical high pressure toward the poles, at least beyond the polar circles. Also, the air of the temperate zones is caught up into a vast "polar whirl" turning from west to east. This turning movement seems to be of the nature of an ordinary cyclone: the air of the lower strata approaches the centre, and that of the upper strata is drawn away, with altitude, from the surface of the earth, up to the highest altitudes of which we have any cognisance.

6. The upper layers of the atmosphere in the temperate zones extend over the high pressures of the tropics and descend there.

7. The irregularities which we find on the surface of the earth, especially in the monsoon regions of Asia, generally disappear at the level of the lower or intermediary clouds.

8. We must therefore give up absolutely the idea of a vertical circulation between the tropics and the poles, which has been hitherto accepted by Ferrel and James Thomson.

Regenwaarnemingen in Nederlandsch-Indie. Drie en Twintigste Jaargang 1901. Batavia, 1902. 8vo. 476 pp.

This contains daily records of rainfall at 224 stations in Java and the

neighbouring islands. A table is also given showing the mean monthly rainfall at all the stations for the 23 years 1879-1901.

U.S. Department of Agriculture. Weather Bureau. Report of the Chief of the Weather Bureau, 1901-1902. Washington, 1902. 4to. xxv. + 342 pp.

In addition to Prof. Willis L. Moore's Report on the operations of the Weather Bureau during the fiscal year ending June 30, 1902, this contains climatology tables of temperature, pressure, wind, rainfall, etc., at the various stations in connection with the Weather Bureau for the year 1901.

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THE PASSAGE OF SOUND THROUGH THE ATMOSPHERE.

By C. V. BOYS, F.R.S.

[A Lecture delivered before the Royal Meteorological Society, March 18, 1903.]

OBSERVATIONS have frequently been made of the anomalous manner in which sound either passes to great distances or fails to pass to moderate distances, *i.e.* of the exceptional transparency or opacity of the atmosphere to sound. I do not know that I could do better than refer to the paper[1] of Mr. W. Marriott which gives an account of his systematic observation of the audibility of Big Ben as an example of unusual completeness and accuracy of the type of observation to which I am referring. My object to-night is not to give examples of observations of this kind, however interesting they may be, but to attempt, I fear very imperfectly, to give some account of the physical causes of such anomalous behaviour.

As is the case with the behaviour of bodies in motion on which the science of dynamics is founded, in which our every day experience is at variance with the fundamental laws, so in acoustics all the laws which ought to belong to the subject are obviously defied daily. We are told in dynamics that a thing which is moving will, unless force be applied to it, continue to move at the same speed and in the same direction for ever. The fact that no one ever saw such an action is the cause, I believe, that dynamics presents a greater difficulty to the student than statics does. All the ideas have to gradually soak in, for they are all contrary to our daily experience—that is, they seem contrary. People constantly ask what it is that makes a free-wheel bicycle go when it is not actually being pedalled? Similarly with sound, which we know to be transmitted as a compression and rarefaction wave in the air,—I am, of course, assuming this to be common knowledge, and I shall not do anything to prove it experimentally or otherwise,—such a wave propagation should be subject to all such laws as linear propagation, shadows,

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xx p. 243

reflection, refraction, diffraction, and pretty well all the laws of optics except perhaps polarisation; but again our daily experience tells us—I should say seems to tell us—that none of this is true. You turn your back to any one and speak, and you are heard; you speak behind a screen, and you are heard; you hold a mirror, when in such a position, so that you may be seen, but you are not heard appreciably better. You go out of doors, and you do observe an echo or reflection of sound, but it is imperfect; and a cliff or a mountain, far too rough in appearance to reflect anything, seem to reflect even more perfectly than a smooth wall. You listen for a distant sound: on one occasion you may hear it miles away; on another, when the air is fairly still and clear, you do not hear it at all. These, and many others, are our familiar experiences which suggest that sound does not behave as light does, but is essentially erratic.

Before saying more on the differences and similarities of the behaviour of sound and of light, let me refer to a wave on the surface of water. Here our experience tells us that a wave is reflected from a vertical wall or smooth cliff. It need not be so very smooth either; provided the inequalities are much less than the length of the water wave, *i.e.* distance from crest to crest, the reflection, which is the aggregate of all the elementary effects, will be a good wave similar to its state before reflection. If the waves were, say, 20 ft. from crest to crest, the wall might have irregularities of a few feet, and still a good reflected wave would be produced—just about as good, in fact, as if the wall were of polished granite. If, however, the water waves were much smaller, such irregularities would be fatal to regular reflection. Let us therefore go to the other extreme and consider ripples on water, *i.e.* waves of such extreme minuteness—a few hundredths of an inch only—that several hundreds pass any point in a second, and so are entirely invisible. The electric spark, however, or stroboscopic illumination, reveals their presence, and may be made to fix them on a photographic plate. I am able to show some of these photographs, and you will admit that their sharpness and precision are such that they look almost more like diagrams of what waves ought to be rather than what we might expect from water or mercury. They show with perfection reflection from a plane surface, reflection from a curved surface, shadows, the formation of images, refraction, interference, and diffraction. In fact, they present the precision of optical law. An ocean wave brought into a laboratory could not be made to show any of these things. An ocean wave, though it may be reflected from a rough cliff, is not reflected from a smooth board such as a drawing-board fastened to a post, nor does such a board prevent the wave from passing behind it. If the board were a quarter of a mile long, and deep in proportion, and were properly secured, it would reflect the waves, and the water behind it would be fairly still.

It is merely a question of size. The instrument must be so large that it extends over a great many wave lengths; its surface need not be smooth, provided that the inequalities are not greater than a small fraction of a wave length. Hence the difficulty of experiments in the laboratory with liquid waves of ordinary size—the apparatus cannot be made big enough. Make the waves as small as possible, *i.e.* employ capillary ripples, and reflectors and other appliances only an inch or two

across are big enough, as I have shown you, to make the little water waves obey the usual optical laws.

I have dwelt at this great length on one class of wave phenomena because it really is the key to the subject I am going to discuss, and because it has the advantage of being more familiar and tangible than the corresponding phenomena in light or sound.

It also indicates how it is that it is almost impossible to make any experiments upon my subject as indicated by the title; for, as the sound waves of my voice, say, are several feet long, I cannot expect to make a successful experiment with apparatus less than 100 ft. or so across, and that, to say the least, is cumbersome. The only apparatus available is that provided by the existence of large buildings, of cliffs, and of mountains. The announcement then that this lecture is to be illustrated by experiments puts me under the necessity of using the shortest sound waves I can get—corresponding, in fact, to the ripples already shown. As Lord Rayleigh has so admirably shown, it is possible, by producing a note of the highest pitch that can be heard, or, better still, by producing notes that are so high that we cannot hear them at all, to reduce the distance between successive waves in the air from several feet to less than an inch; and though that is still large, it is easy to prepare portable apparatus which includes a dozen or two wave lengths, and that is sufficient to show in the laboratory that the ordinary optical laws are fairly well obeyed by sound. In this way the linear propagation, the shadow, reflection and refraction, the formation of a focus, and diffraction may all be shown. I have brought some extemporised and rough apparatus with this object, but all I can do is very imperfectly to repeat some of Lord Rayleigh's experiments.

It may be interesting to notice that when a sound wave is passing through the air there is, as we all know, alternate condensation and rarefaction. Now even though this may be very small, the variation amounting generally to far less than $\frac{1}{1000}$ of the whole pressure, the air so compressed or rarefied is to an almost infinitesimal extent more slowly or more quickly traversable by light, *i.e.* it is almost infinitesimally more or less refractive to light. This opens up the possibility of seeing a sound wave.

For instance, Prof. Mack and I independently made photographs of rifle bullets travelling at a speed greater than that of sound. In such cases there is no time for the air to pass round and get to the other side of the bullet. It is compressed in front so that a hyperbolic-looking wave is produced, the limbs travelling outwards with the velocity of sound, while the highly compressed wave in front travels two or perhaps three times as fast according to the speed of the bullet. I am able to exhibit a few of these photographs, and one of a diagram which shows how the shell of compressed air acts like a prism on the light by which they were photographed. In these the perfect action of a reflector and diffraction at the end of a reflected wave, are conspicuous, as are other curious properties which I have described from time to time. It is a corresponding wave to this of compressed air which a meteor produces, but it must have a steeper angle, which gives rise to the so-called explosion which on rare occasions has been heard after a meteor has passed. Vieille has examined these photographs and has calculated the resistance to the bullet, which

agrees so closely with that which is known that he has felt justified in extending them to much higher velocities. Thus at 10,000 metres a second, which is quite a moderate meteoric speed, the air should attain a temperature by adiabatic compression of nearly 50,000° ! No wonder then that meteors blaze up in so hot a bath.

Passing now from these waves of high compression to the sound wave of a strong explosion, I am able to bring to your notice a very curious observation made several years ago by Mr. Ryves. Mr. Ryves made all the ballistic observations for the Maxim Nordenfeldt Company; and not only this, he seemed to live surrounded by high explosives. He had occasion once to fire off a large quantity of waste explosive, some 70 odd pounds, and it happened at the time that the sun was shining brightly. He noticed at the moment of the explosion a black ring develop and expand with lightning rapidity, and he heard and felt the shock as the ring passed him. This was soon after he had heard the explanation of the formation of a shadow of the wave round a bullet which I have just described, and he rightly concluded that the explosion wave cast a shadow in the same way. Soon after, having 100 or more pounds of waste explosive, he asked me to come and see the ring produced, and I asked Mr. Paul to bring his animatograph to try and catch it, and we were fortunate in getting a bright sunny day. The difficulty that I feared actually was too great for us. The ring shadow would expand at over 1000 ft. a second. Supposing, therefore, it to be 2 ft. broad, an exposure of $\frac{1}{500}$ second would be needed to get any of it really black, and that we could not attain. Still, I hoped that some evidence of the expanding ring would be found. I had with me an ordinary half-plate camera, and I stood 100 ft. away, but I was so busy trying to arrange to make the exposure within $\frac{1}{10}$ second of the explosion so as to catch the complete ring, that I had forgotten to think of looking for it; yet it was so conspicuous that it forced its existence on me. I should say some black powder was added to make a smoke, so that there should be something to see after the ring had gone. Mr. Paul has kindly sent the animatograph and the photograph that he took, and though you cannot, as I feared, see the black ring in any one of the photographs, when the animatograph works you will be sensible of a shadowy ring phenomenon growing at the alarming speed I have mentioned.

The bullet wave is a strong wave—this last was a very strong wave. Prof. R. W. Wood, among others, has photographed sound waves produced by an electric spark, and I am able to show some of his results on the screen. The forms of the wave fronts produced after reflection are, where spherical aberration exists, very curious; but to show that they are, after all, just what geometry would require, Prof. Wood made a large number of geometrical diagrams of closely succeeding positions, and some of these Mr. Paul has kindly sent to be run through the animatograph now.

By way of contrast to these violent single waves, the ordinary sounds of speech and music in the air, to which I first referred, can be made visible, not by any mechanical devices with accuracy, but by purely optical means; but the crude refraction which was sufficient for the strong wave must now be replaced by a delicate interference method

first adapted to the purpose by Rapp. I am able to show a diagram of his apparatus and some of his results. I have repeated some of his experiments with a different interference device, originally designed by Michaelson, but made and lent to me for the purpose by Mr. Edser. The experiments are not suitable for exhibition in a large room.

I have now indicated, in spite of our first impression, that both water waves and sound waves do follow the proper laws of wave motion, *i.e.* when the apparatus is big enough or the waves small enough—laws which are so perfectly obeyed by light that we call them the optical laws. Here it is curious to remark that if we do the converse for light that we have for water waves and sound waves, that is, prepare apparatus so small that even a light wave of say $\frac{1}{40000}$ inch is appreciable, in comparison, we find that light behaves like sound, it goes round corners, and fails to produce perfect images. It is, in fact, for this reason that it is impossible to magnify usefully more than a definite amount with a telescope of any given size, and that a microscope can never separate two objects nearer than about $\frac{1}{150000}$ inch. Mr. Croft has made some beautiful photographs of some of these diffraction phenomena, which by his kindness I am able to show to-night. All I want to insist upon now is that light is really imperfect as sound is if the surfaces that operate are small enough.

Light, with all the perfection with which it obeys the recognised laws, nevertheless, on the large scale, in consequence of variations of density in the air, gives rise at times to strange phenomena. It is because I want to reflect the corresponding acoustical phenomena that I must now refer to them. In the first place, in consequence of the gradual decrease of density upwards, light does not travel in a straight horizontal line, but is usually curved to an extent of about one-sixth of the curvature of the earth. It describes a curve, in other words, in a vertical plane of about 24,000 miles radius. Thus it is that when the sun or moon have geometrically just set they appear just above the horizon, and a total eclipse of the moon can be observed while the sun is still wholly visible on the opposite side of the earth at the same time. This is the usual state of affairs. If the ground is very cold and the temperature rapidly increases upwards, the fall of density becomes intensified and light travels in a still more curved path. It would not require much to make it move in a path equal in curvature to the surface of the earth, so that if you could see far enough you would be able to see the back of your head by looking straight ahead.

Now when the conditions are reversed, and cold air is resting on warmer ground, it sometimes happens that the change is sufficiently rapid for light to gradually curve the other way and mirage results, and often the reversing layer of air is so thin that the mirage can only be seen at one level. Then distant trees or mountains may be seen double or multiple, as there may be two or more paths along which light may pass from the object to the eye.

Then there is a variety of this phenomenon known as "looming," when very distant objects, often too far to be seen under normal conditions, appear near or largely magnified. This results from such a variation in the curvature of neighbouring rays as to make rays from points which should appear close together to enter the eye at an unduly

large angle. These phenomena are well known, and I only refer to them as the acoustical analogues are so marked.

Unlike light, the velocity of sound is not affected by the density of the air but it is by the temperature. As, therefore, the temperature usually falls with increasing altitude, the usual condition is, that sound travels more quickly near the ground than higher up. This will especially be the case on a warm, quiet, sunny day. If, therefore, on such an occasion it were to happen that the air were uniformly stratified in layers of decreasing temperature, sound would not travel in straight lines but in curved lines with the concavity upwards. One person, therefore, could not be heard well by another at a distance, as the ground intercepting the curved proper direction of an acoustical ray would cast a shadow. This is the opposite of mirage. But such conditions as those described are not favourable for the propagation of sound for other reasons. Where the air is much warmer below than it is above, it is in an unstable state, and chimneys of ascending and occasionally of rotating air may be rising in a multitude of places without any visible sign of their existence. Sound, meeting with these chimneys, is, as Tyndall showed long ago, badly dispersed. It may in some small degree be reflected where rapid variations of density occur, but it is likely that a Döppler effect may be produced, altering the direction of the sound in the chimney, altering the phase to right and left where rotation occurs, and thus leaving any sound that emerges irregularly out of phase with other sound that has missed the chimney. A multitude of these, then, will produce the same blurring on sound that imperfectly mixed whisky and water does on light.

On the other hand, a quiet night with the ground colder than the air tends to reverse the curvature of the sound rays, so that the ground does not form an obstruction and sound is heard well. Above all, a gentle wind, imperceptible on the ground but increasing gradually upwards, adds its velocity to the sound velocity one way and subtracts it the other, and so up the wind the resultant velocity becomes less upwards and sound rays are strongly bent so as to be concave upwards and the ground intercepts all the sound. Down the wind, on the other hand, the velocity is greater upwards, and rays starting possibly at a number of different inclinations from a source of sound may, after some miles, all converge on a listener, and so he may observe acoustical looming to the amazing extent that we sometimes experience.

This lecture was illustrated by Experiments, Animatographs and Lantern Slides.

THE PREVALENCE OF GALES ON THE COASTS OF THE BRITISH ISLANDS DURING THE 30 YEARS 1871–1900.

(SECOND PAPER.)

BY FREDERICK J. BRODIE, F.R.Met.Soc.

[Read April 15, 1903.]

IN a former paper on this subject, read before the Society a year ago,[1] a Table was given showing the number of gales experienced on the coasts of the British Islands during each of the 30 years 1871-1900. In this table the storms of the period were grouped according to the extent of coast affected, varying widely in degree, from a small portion only of one district (quoted as a "local" gale) to the whole or the greater part of the United Kingdom (quoted as a "general" gale). Owing to want of time, it was found impossible to apply this classification to other branches of the discussion, and in subsequent portions of the paper the gales were dealt with irrespective of the size or position of the area affected. The subject has since been examined in greater detail, and in the present paper some results are given for each of the four principal quadrants, the Western, the Northern, the Southern, and the Eastern. In a strict sense the Western division has been taken to include Ireland and the neighbouring Seas and Channels; the Northern division, Scotland only; the Southern division, the English Channel; and the Eastern division, that portion of the coast lying between the mouths of the Thames and the Tweed. No account has been taken of gales affecting a small portion only of one coast. Thus, many of the storms which visit our North coasts are felt also in the extreme northern parts of the Eastern and the Western quadrants; while in other instances a gale affecting the West coasts has been found to extend to adjacent parts of the Northern and Southern quadrants. In all these cases the gale has been entered only against the coast on which it was general. Had we included in the list of East coast gales those extending from Scotland as far South as Northumberland or Durham, or in the list of South coast gales those spreading from the Westward to the mouth of the English Channel, the number of storms in each of these divisions would have been much larger than appears in this paper.

The data employed in this, as in the earlier discussion, is that collected annually in the Meteorological Office for the purpose of testing the accuracy of the Storm Warnings issued to our coasts. A description of this material was given in the former paper, and it is therefore unnecessary to recapitulate the sources from which it is derived. I would, however, again express my great indebtedness to the Meteorological Council for their kindness in permitting me to make use of unpublished data of such inestimable value.

The definition of a gale adopted in this paper has been a wind blowing with a force of at least 8 by the Beaufort Scale, or with a velocity of at least 40 miles an hour (nominal[2]), at a large majority of stations in the

[1] *Quarterly Journal Royal Meteorological Society*, vol. xxviii. p. 121.

[2] By the expression "nominal," we mean a wind velocity measured by the Robinson anemometer, and converted by the use of the factor 3·0, a practice still employed by the Meteorological Office.

TABLE I.—NUMBER OF GALES EXPERIENCED ON THE WEST COASTS OF THE BRITISH ISLANDS IN EACH MONTH, IN EACH SEASON, AND IN EACH YEAR OF THE 30 YEARS 1871-1900.

YEARS.	January.			February.			March.			April.			May.			June.			July.			August.			September.			October.		
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871	5	1	2	5	1	…	5	…	…	2	…	…	…	…	…	…	…	…	…	…	…	1	…	…	1	…	…	5	…	…
1872	7	3	1	2	…	…	1	…	…	1	…	…	1	…	…	…	…	…	…	…	…	…	…	…	2	…	…	3	1	…
1873	8	…	3	2	…	…	3	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1	…	…	1	…	…	4	…	…
1874	5	…	…	3	2	…	4	…	1	2	1	…	…	…	…	…	…	…	…	…	…	…	…	…	1	…	…	5	…	1
1875	7	…	1	1	…	…	2	…	…	…	…	…	1	…	…	1	…	…	…	…	…	…	…	…	3	1	…	1	…	…
1876	2	…	…	3	…	…	5	…	2	2	…	1	…	…	…	…	…	…	…	…	…	2	…	…	2	…	…	2	1	…
1877	9	2	3	4	1	1	2	…	1	2	…	…	1	…	…	2	…	1	…	…	…	1	…	…	1	…	…	7	1	…
1878	5	…	2	1	…	…	3	…	1	1	…	…	1	…	…	…	…	…	…	…	…	1	…	…	3	…	1	5	1	1
1879	6	…	…	…	…	…	3	…	…	1	…	…	…	…	…	3	…	…	2	…	…	3	…	…	2	…	…	1	…	…
1880	2	…	…	7	…	1	3	…	1	2	…	…	1	…	…	…	…	…	…	…	…	1	…	…	1	…	…	3	1	…
1881	1	…	…	3	1	1	1	…	1	1	…	…	1	…	…	…	…	…	…	…	…	1	…	…	…	…	…	7	2	…
1882	6	…	1	5	…	…	2	…	…	2	…	…	2	…	…	1	…	…	…	…	…	1	…	1	2	…	…	2	1	…
1883	8	2	…	7	1	…	4	…	…	2	…	…	…	…	…	…	…	…	…	…	…	2	…	…	2	1	…	4	…	2
1884	3	2	…	4	2	1	3	…	…	…	…	…	2	…	…	…	…	…	…	…	…	…	…	…	2	…	…	4	…	…
1885	4	…	…	4	1	…	3	…	…	2	…	…	…	…	…	…	…	…	…	…	…	1	…	…	2	…	…	2	…	…
1886	7	…	…	…	…	…	6	1	1	3	…	2	2	…	…	…	…	…	1	…	…	…	…	…	4	…	…	4	1	…
1887	3	…	…	4	…	…	…	…	…	…	…	…	1	…	1	…	…	…	…	…	…	…	…	…	2	…	…	…	…	…
1888	3	…	2	1	…	…	3	…	…	1	…	…	3	…	1	…	…	…	1	…	…	2	…	…	…	…	…	1	…	…
1889	2	…	…	3	2	…	1	…	1	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	2	1	…
1890	11	4	4	1	…	…	2	…	1	1	…	…	…	…	…	1	…	…	2	…	…	3	…	…	1	…	1	4	…	2
1891	4	…	1	…	…	…	4	…	…	…	…	…	1	…	…	…	…	…	1	…	…	1	…	1	3	1	1	6	2	2
1892	4	1	…	4	2	…	1	…	…	1	…	…	…	…	…	…	…	…	2	…	…	2	…	…	2	…	…	4	…	1
1893	4	…	…	5	1	1	1	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1	…	…	…	…	…	3	…	…
1894	10	…	3	8	1	…	4	…	1	2	…	…	…	…	…	…	…	…	…	…	…	1	…	…	…	…	…	3	…	1
1895	5	1	2	2	…	1	3	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1	…	…	3	…	1
1896	2	…	…	…	…	…	9	1	1	2	…	…	…	…	…	…	…	…	…	…	…	1	…	…	4	1	1	4	1	…
1897	4	…	…	4	…	…	7	…	3	2	…	…	1	…	…	1	…	…	…	…	…	2	…	…	1	…	1	2	…	1
1898	2	…	…	3	1	1	2	…	…	1	…	…	2	…	…	…	…	…	…	…	…	1	…	…	1	…	…	5	…	…
1899	6	2	1	3	…	…	1	…	…	2	1	…	…	…	…	…	…	…	…	…	…	…	…	…	4	…	1	3	…	…
1900	8	…	…	5	…	…	…	…	…	3	…	1	2	…	…	1	…	…	…	…	…	2	…	1	2	…	…	4	…	…
Totals	153	18	26	94	16	7	88	2	15	38	2	4	22	…	2	10	…	1	9	…	…	31	…	3	50	4	6	103	13	12
Means	5·1	0·6	0·9	3·1	0·5	0·2	2·9	0·1	0·5	1·3	0·1	0·1	0·7	…	0·1	0·3	…	…	0·3	…	…	1·0	…	0·1	1·7	0·1	0·2	3·4	0·4	0·4

TABLE I.—*Continued.*

Years.	November.			December.			The Seasons. The Spring.			The Summer.			The Autumn.			The Winter.			The Six Months. The Summer Half-year.			The Winter Half-year.			The Entire Year.		
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871 . . .	3	...	...	3	...	1	7	...	...	1	...	...	9	...	...	13	2	2	4	...	...	25	5	3	30	2	3
1872 . . .	7	2	1	7	1	...	3	...	...	...	...	...	12	3	1	12	3	2	4	...	...	21	3	2	31	7	2
1873 . . .	4	1	...	1	...	...	3	...	...	1	...	...	9	1	...	17	1	3	2	...	...	30	4	4	24	1	3
1874 . . .	2	...	1	3	1	1	6	1	1	...	...	...	8	...	2	9	2	...	3	1	...	21	3	1	25	4	4
1875 . . .	4	...	2	3	...	...	3	...	...	1	...	...	8	1	2	11	1	2	5	1	...	20	1	4	23	1	3
1876 . . .	3	...	...	7	2	1	7	...	3	2	...	...	7	1	...	8	...	...	6	...	1	18	...	4	28	3	4
1877 . . .	8	2	...	4	...	...	5	...	1	3	...	1	16	3	...	20	5	5	7	...	1	27	6	6	41	6	6
1878 . . .	4	...	2	3	...	...	5	...	1	1	...	...	12	1	4	10	...	2	6	...	1	28	3	3	27	1	7
1879 . . .	3	...	1	4	1	1	4	...	...	8	...	...	6	...	1	9	...	...	11	...	...	21	1	3	28	1	2
1880 . . .	6	...	2	1	...	1	6	...	1	1	...	...	10	1	2	13	1	2	5	...	...	20	1	4	27	1	5
1881 . . .	9	2	1	5	...	1	3	...	1	1	...	...	16	4	1	5	1	2	3	...	...	15	2	5	29	5	4
1882 . . .	9	1	1	4	...	...	6	...	...	2	...	1	13	2	1	16	...	2	8	...	1	34	4	3	36	2	3
1883 . . .	6	...	...	4	1	...	6	...	...	2	...	...	12	1	2	19	3	...	6	1	...	34	5	1	39	5	2
1884 . . .	2	...	...	6	...	1	5	...	...	...	...	...	8	...	...	11	5	1	4	...	...	24	5	3	26	4	2
1885 . . .	2	...	...	2	...	1	5	...	...	1	...	...	6	...	...	14	1	1	5	...	...	23	1	1	22	1	1
1886 . . .	3	...	2	4	1	...	11	1	3	1	...	...	11	1	2	9	...	1	10	...	2	19	1	2	34	3	5
1887 . . .	4	1	...	5	...	...	1	...	1	...	...	...	6	1	...	11	1	...	3	...	1	18	2	2	19	1	1
1888 . . .	12	...	2	4	...	...	7	...	1	3	...	...	13	...	2	9	...	2	7	...	1	16	1	2	31	...	5
1889 . . .	3	...	1	4	...	...	1	...	1	...	...	...	5	1	1	9	2	...	...	...	...	23	2	3	15	3	2
1890 . . .	8	1	1	3	...	...	3	...	1	6	...	...	13	1	4	16	4	4	8	...	1	23	5	6	37	5	9
1891 . . .	5	1	...	9	1	4	5	...	...	2	...	1	14	4	3	7	...	1	6	1	2	23	1	4	34	5	9
1892 . . .	4	...	...	5	...	...	2	...	...	4	...	...	10	...	1	17	4	4	7	...	...	29	7	6	29	3	1
1893 . . .	4	1	1	9	2	3	1	...	...	1	...	...	7	1	1	14	1	1	1	...	...	23	1	2	27	4	5
1894 . . .	5	...	2	6	2	1	6	...	1	1	...	...	8	...	3	27	3	6	3	...	...	38	4	8	39	3	8
1895 . . .	7	1	2	4	1	3	3	...	...	...	...	...	11	1	3	13	3	4	1	...	...	24	3	7	25	3	9
1896 . . .	1	...	...	6	...	1	11	1	1	1	...	...	9	2	1	6	1	3	7	1	1	25	3	7	29	3	3
1897 . . .	3	1	...	8	1	1	10	...	3	3	...	...	6	1	2	14	...	1	7	...	1	26	1	4	35	2	6
1898 . . .	5	...	1	6	1	1	5	...	...	1	...	...	11	...	1	13	2	2	5	...	...	20	3	3	28	2	3
1899 . . .	6	1	1	4	...	1	3	1	...	...	...	...	13	1	2	15	3	2	6	1	1	26	3	3	29	4	4
1900 . . .	5	...	...	8	2	...	5	...	1	3	...	1	11	...	...	17	...	1	10	...	2	26	1	2	·40	2	2
Totals . . .	147	15	24	142	17	23	148	4	21	50	...	4	300	32	42	384	49	56	160	6	16	720	82	108	887	87	123
Means . . .	4·9	0·5	0·8	4·7	0·6	0·8	4·9	0·1	0·7	1·7	...	0·1	10·0	1·1	1·4	12·8	1·6	1·9	5·3	0·2	0·5	24·0	2·7	3·6	29·6	2·9	4·1

Note.—The figures under the letter S denote, in each case, the number of Severe Gales, and those under the letter P the number of Partially Severe Gales.

district. A severe gale has been taken to mean a wind blowing with a force of at least 10 (Beaufort Scale), or with a velocity of at least 60 miles an hour, at more than half the stations; while a partially severe gale has been taken to mean a wind of similar strength recorded at less than half the stations in the district. No notice has been taken of severe gales reported only at one station; in very many cases these would appear to be the result simply of over-estimation.

The present paper may be divided into three sections, the first giving tabular statements showing for each of the 30 years the number of gales experienced in each division; the second giving the mean prevalence of gales at various times in the year; and the third giving some information as to the mean direction from which gales blow on various parts of our coasts.

Gales on the West Coasts.

Table I. shows for each month, for each season, and for each year of the 30 years 1871-1900, the number of gales experienced on our West coasts, together with means for the whole period. The seasonal divisions adopted are those commonly employed in meteorological work, the Spring season comprising the three months March, April, and May; the Summer, June, July, and August; the Autumn, September, October, and November; and the Winter, December, January, and February. The summer half-year comprises the six months, April to September; and the winter half-year the six months, October to the following March. In this and the three following tables the first winter given in the series is that running from December 1870 to February 1871, and the last winter, that from December 1899 to February 1900. In a similar way the first winter half-year is that running from October 1870 to March 1871, and the last winter half-year, that from October 1899 to March 1900.

It will be seen from the table that the mean annual number of gales on our West coasts was 29·6, of which 2·9 were severe and 4·1 partially severe. Bearing in mind the region from which most of our storms proceed, it is not surprising to find that gales were more common in this than in any other division. In the North the mean annual number (26) was, it is true, not much smaller, but in the South the average was only 19, while on our East coasts the average number (less than 16) was little more than half that recorded in the West. The stormiest year of the whole 30 was 1877, with a total of 41 gales, of which 6 were severe and 6 partially severe. In 1900 the total was nearly as high, but of the 40 gales which then occurred, only 2 were severe and 2 partially severe. Next to 1877 and 1900, the stormiest years in the West were 1883 and 1894, each with a total of 39 gales; in the former year 7, and in the latter year 11 of the 39 were either severe or partially severe. The quietest year of the series was 1889, with a total of only 15 gales, and next to this 1887, with a total of 19, and 1885 with a total of 22.

Of the total number of gales in the West, 82 per cent occurred in the winter half-year and only 18 in the summer half, the stormiest six months being that of 1893-94 when there were 38 gales (more than half as many again as the average), of which 4 were severe and 8 partially severe. The quietest winter half-year was that of 1880-81, with a total of only 15 gales; the next in order being those of 1887-88, with a total of 16, and

those of 1875-76 and 1886-87, each with a total of 18. The stormiest summer half-year occurred in 1879, a season memorable also on account of its persistent rains and low temperatures, but in the summer halves of 1886 and 1900, the total number of gales was very nearly as large. No gales were reported in the summer half of 1889, and only 1 in 1893 and 1895.

The seasonal results show that of all the gales which occurred in the West, about 43 per cent were experienced in the winter, 34 per cent in the autumn, 17 per cent in the spring, and 6 per cent in the summer. The stormiest winter by far was that of 1893-94, the stormiest autumns those of 1877 and 1881, the stormiest springs those of 1886 and 1896, and the worst summer that of 1879. In seven summers out of the 30, viz. those of 1872, 1874, 1884, 1887, 1889, 1895, and 1899, there were no gales of any consequence in the West.

The monthly results for the Western division show that storms were most prevalent in January, but nearly as common in November and December. The stormiest month in the whole 30-year period was January 1890. The total number of gales was somewhat larger in November 1888; but whereas in the latter case there were 12 gales of which none were severe and only 2 partially severe, in the former case there were, out of a total of 11 gales, 4 severe ones and 4 partially severe. The quietest months in the year were June and July, the number of gales in each month being very similar; August was rougher than May, and September more stormy than April.

Gales on the North Coasts.

Table II. gives, in a similar manner to Table I., the number of gales experienced on the North coasts of our islands. The mean annual number in this division was 25·7, of which 1·3 were severe and 3·7 partially severe. The greatest number in any one year occurred, as in the West, in 1877, when 40 gales were experienced, 8 of these being partially severe, but only 1 generally so. The number of severe and partially severe gales combined was equally large in 1883 and 1894, and was even larger in 1884, but in the year last mentioned the number of gales of all kinds was not appreciably in excess of the average. The quietest years of the whole series were 1887 and 1889, each with a total of 15 gales; in the former year none of these were even of partial severity. The well-known tendency which exists for the weather to be at times either warm or cold, dry or wet, is shown also in the matter of wind force, and has often been a source of much perplexity to me in making out my catalogue of gales. For many months together the storms experienced have at times been not only rare in number, but of so half-hearted a character, that in many instances it has been a matter of grave doubt as to whether they should find a place in the list at all. At other times the stormy tendency has been so marked and the gales have blown with so much vigour, that no such hesitancy has ever arisen. The years 1887 and 1889 were, perhaps, those in which a proclivity in favour of quiet weather was most evident. In the former of these two years, not one out of the small total of 15 reported on the North coasts was felt at nearly all the stations in the district.

TABLE II.—NUMBER OF GALES EXPERIENCED ON THE NORTH COASTS OF THE BRITISH ISLANDS IN EACH MONTH, IN EACH SEASON, AND IN EACH YEAR OF THE 30 YEARS 1871-1900.

YEARS.	January.			February.			March.			April.			May.			June.			July.			August.			September.			October.		
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871	2	...	...	5	...	1	3	1	...	1	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...
1872	7	2	...	3	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...
1873	6	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	6	1	...
1874	6	1	1	1	1	...	4	...	1	1	...	1	...	...	...	1	...	...	...	...	...	1	...	...	1	...	...	4	1	...
1875	5	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	2	...	...	3	...	1
1876	4	...	2	4	...	1	5	...	1	1	...	...	...	...	...	...	...	...	1	...	...	2	...	...	...	...	...	3	...	...
1877	8	1	2	4	...	1	4	...	1	3	...	1	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	7	...	1
1878	3	...	...	...	...	...	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	1	5	...	1
1879	4	...	...	1	...	...	5	...	...	1	...	...	1	...	...	...	...	...	1	...	...	...	...	...	2	...	1	1	...	...
1880	2	...	...	7	...	3	3	...	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	1	...
1881	1	...	...	4	...	1	6	...	3	1	...	...	1	...	...	...	...	...	1	...	...	1	...	...	...	...	...	6	1	1
1882	4	1	1	4	...	1	6	...	...	...	...	...	...	...	...	2	...	...	...	...	...	1	...	...	...	...	...	3	...	1
1883	7	...	2	10	1	1	5	1	2	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	...	4	...	1
1884	8	1	3	4	1	1	3	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	1	1
1885	1	...	...	3	1	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	1	4	...	...
1886	3	...	1	...	...	...	3	...	...	3	...	...	1	...	...	1	...	...	...	...	...	...	...	...	1	...	...	2	...	...
1887	2	...	...	4	...	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
1888	4	...	...	...	...	...	3	...	1	1	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...
1889	2	...	1	4	1	1	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
1890	9	1	2	...	...	...	6	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1	6	...	...
1891	4	...	...	2	...	...	5	...	1	2	...	...	1	...	...	...	...	...	...	...	...	1	...	...	3	...	...	6	1	...
1892	6	...	2	2	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...	5	...	...	4	...	...
1893	3	...	...	3	...	2	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	4	...	...
1894	7	...	2	8	1	1	4	...	2	...	...	...	2	...	...	...	...	...	...	...	...	1	...	...	...	...	...	2	...	...
1895	4	...	2	1	...	...	1	...	...	2	...	...	1	...	...	...	...	...	1	...	...	...	...	...	2	...	...	2	...	...
1896	2	...	1	2	...	...	3	...	1	1	...	...	1	...	...	1	...	...	1	...	...	...	...	...	3	...	...	4	...	1
1897	5	...	1	4	...	...	8	...	...	2	...	...	2	...	...	1	...	...	...	...	...	1	...	...	2	...	...	3	...	...
1898	4	...	...	5	1	2	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...
1899	4	...	1	...	...	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	1	...	1	4	...	...	3	...	...
1900	7	...	...	3	1	1	2	...	...	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...
Totals	134	7	25	90	8	17	93	3	15	32	...	3	21	...	...	6	...	...	7	...	...	14	...	1	46	...	4	99	6	8
Means	4·5	0·2	0·8	3·0	0·3	0·6	3·1	0·1	0·5	1·1	...	0·1	0·7	...	...	0·2	...	...	0·2	...	...	0·5	...	...	1·5	...	0·1	3·3	0·2	0·3

TABLE II.—*Continued.*

Years.	November.			December.			The Seasons.												The Six Months.						The Entire Year.		
							The Spring.			The Summer.			The Autumn.			The Winter.			The Summer Half-year.			The Winter Half-year.					
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.*	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871 . . .	3	...	...	2	...	...	5	1	...	1	...	...	5	...	...	9	...	1	4	...	...	16	1	3	20	1	1
1872 . . .	3	...	1	3	...	...	3	...	...	...	...	...	6	...	1	12	2	...	5	...	...	16	2	...	22	2	1
1873 . . .	3	...	1	3	1	1	1	...	...	...	...	...	10	1	1	10	...	1	1	...	...	15	...	2	21	2	3
1874 . . .	1	...	1	3	...	...	5	...	2	2	...	...	6	1	1	10	3	2	4	...	1	23	4	4	23	3	4
1875 . . .	3	...	1	2	1	1	1	...	...	1	...	...	8	...	2	9	...	...	3	...	...	15	1	1	18	1	3
1876 . . .	3	...	...	5	2	1	6	...	1	3	...	...	6	...	...	10	1	4	4	...	...	21	1	7	28	2	5
1877 . . .	7	...	2	5	...	...	8	...	2	...	...	...	15	...	3	17	3	4	5	...	1	27	3	5	40	1	8
1878 . . .	5	...	...	1	...	...	3	1	...	...	...	...	13	...	2	8	...	...	4	...	1	24	1	3	20	1	2
1879 . . .	2	...	...	4	1	...	7	...	...	1	...	...	5	...	1	6	...	...	5	...	1	21	...	1	22	1	1
1880 . . .	6	1	...	5	...	2	6	...	...	...	...	...	9	2	...	13	1	3	4	...	...	19	1	3	29	2	5
1881 . . .	8	1	1	5	...	...	8	...	3	2	...	...	14	2	2	10	...	3	4	...	...	24	2	6	34	2	6
1882 . . .	4	...	...	3	...	...	6	...	...	3	...	...	7	...	1	13	1	2	3	...	...	33	3	4	27	1	3
1883 . . .	4	...	...	4	1	...	6	1	2	1	...	...	10	...	1	20	1	3	4	...	...	32	2	6	38	3	6
1884 . . .	3	...	...	3	...	1	4	...	1	...	...	...	7	1	1	16	3	4	2	...	...	27	3	6	26	3	7
1885 . . .	1	...	1	4	...	1	3	...	...	1	...	...	8	...	2	7	1	1	4	...	1	16	2	2	20	1	3
1886 . . .	3	...	...	3	1	...	7	...	...	1	...	...	6	...	...	7	...	2	6	...	...	15	...	3	20	1	1
1887 . . .	3	...	...	3	...	...	2	...	...	...	...	...	4	...	...	9	1	...	1	...	...	15	1	...	15	...	...
1888 . . .	9	1	4	1	...	...	7	...	1	...	...	...	12	1	4	7	...	...	4	...	...	14	...	1	24	1	5
1889 . . .	2	...	...	2	...	...	3	...	...	...	...	...	4	...	...	7	1	2	2	...	...	21	2	6	15	1	2
1890 . . .	7	...	1	3	...	...	7	...	...	...	...	...	15	...	2	11	1	2	3	...	1	20	1	2	34	1	4
1891 . . .	3	...	...	6	...	1	8	...	1	1	...	...	12	1	...	9	...	...	7	...	...	27	...	2	33	1	2
1892 . . .	3	...	...	2	...	1	1	...	...	2	...	...	12	...	...	14	...	3	8	...	...	23	1	3	25	...	3
1893 . . .	6	1	...	6	1	1	2	...	1	1	...	...	11	1	...	8	...	3	2	...	...	17	...	4	26	2	4
1894 . . .	2	...	...	5	1	2	6	...	2	1	...	...	4	...	...	21	2	4	3	...	...	35	3	6	31	2	7
1895 . . .	4	...	1	4	1	1	4	...	...	1	...	...	8	...	1	10	1	4	6	...	...	15	1	4	22	1	4
1896 . . .	1	...	...	3	...	1	5	...	1	2	...	...	8	...	1	8	1	2	7	...	...	17	1	4	22	...	4
1897 . . .	2	1	...	5	...	2	12	...	...	2	...	...	7	1	...	12	...	2	8	...	...	25	...	3	35	1	3
1898 . . .	3	...	...	9	...	3	2	...	...	...	...	...	6	...	...	14	1	4	1	...	...	20	2	4	26	1	5
1899 . . .	5	...	2	4	...	1	2	...	1	1	...	1	12	...	2	13	...	4	6	...	2	20	...	4	23	...	6
1900 . . .	2	...	...	9	1	1	6	...	...	...	...	...	6	...	...	14	1	2	6	...	...	24	1	4	31	2	2
Totals . . .	111	5	16	117	11	21	146	3	18	27	...	1	256	11	28	334	25	62	126	...	8	637	39	103	770	40	110
Means . . .	3·7	0·2	0·5	3·9	0·4	0·7	4·9	0·1	0·6	0·9	...	...	8·5	0·4	0·9	11·1	0·8	2·1	4·2	...	0·3	21·2	1·3	3·4	25·7	1·3	3·7

Note.—The figures under the letter S denote, in each case, the number of Severe Gales, and those under the letter P the number of Partially Severe Gales.

Of the total number of gales in this division 84 per cent occurred in the winter half of the year, and only 16 per cent in the summer half, the proportion of winter gales being consequently rather larger than in the West. The stormiest winter half was that of 1893-94, when there were 35 gales, 3 of which were severe and 6 partially so. The number of severe and partially severe gales combined was, however, equally large in the six months, October 1883 to March 1884, and was very nearly as large in the six winter halves, 1873-74, 1875-76, 1876-77, 1880-81, 1882-83, and 1888-89. The quietest winter half-year was that of 1887-88, with a total of only 14 gales, only 1 of which was even partially severe; the total number was, however, almost equally small in 1872-73, 1874-75, 1885-86, 1886-87, and 1894-95. The stormiest summer half-years in the North were those of 1892 and 1897, each with a total of 8 gales; the quietest being those of 1873, 1887, and 1898, when only 1 was recorded. During the summer half-year there were throughout the whole 30-years period no gales that could be classed as generally severe, and only 8 that were even partially severe. Of the 8 recorded, 2 occurred in 1899 and 1 in each of the three successive years 1877 to 1879.

The seasonal results show that of all the gales which occurred in the North about 44 per cent were experienced in the winter, 34 per cent in the autumn, 19 per cent in the spring, and little more than 3 per cent in the summer. Spring gales were therefore somewhat more frequent than in the Western division, while summer gales were less numerous. The stormiest winter of the series was that of 1893-94; the stormiest autumns those of 1877 and 1890; the stormiest spring that of 1897, and the stormiest summers those of 1876 and 1882. In 12 summers out of the 30 there were no gales of any consequence on our Northern coasts. It is perhaps a little unfortunate that the exclusion of all local gales from our list (that is gales occurring in a small portion only of one division) should have necessitated the omission of one of the worst summer storms ever recorded in this division. On June 25, 1890, a Westerly gale of great severity swept over the North of Scotland and occasioned a large number of fatal disasters among the fishing fleets; the gale was apparently not felt further south than Aberdeen.

The monthly means for the North coasts show that gales were most frequent in January, and next to this in December and November; the number in March was slightly greater than in February. The largest number of gales in any one month was in February 1883, when there were as many as 10, of which 1 was severe and 1 partially severe. The weather may, however, be said to have been equally stormy in November 1888, for while the total number of gales in that month was only 9, five of them were either wholly or partially severe. June and July were again the quietest months, the number of gales in each being very similar. On our Northern coasts, August appears to be less stormy than May,—a feature not shown in any of the other four divisions.

Gales on the South Coasts.

From Table III., giving the results for the South coasts, we see that in this part of the country the mean annual number of storms was 19·1,

of which 1·5 were severe and 2·2 partially severe. The number was much smaller than in the West, and appreciably smaller than in the North, but was somewhat larger than in the East. The stormiest year, by far, of the whole series was 1883, with a total of 34 gales, 3 of which were severe and 4 partially severe. The nearest approach to such a number was in 1885; the total then was not far short of that reached two years earlier, but of the 31 gales which occurred none were wholly, and only 3 partially severe. The smallest number of gales occurred in 1875, the total then being 10, of which only 2 were even partially severe. In 3 years, viz. 1873, 1879, and 1898, there were no severe or partially severe gales.

Of the total number of gales in the South, 80 per cent occurred in the winter half of the year and 20 per cent in the summer half, the proportion in the summer months being somewhat higher than in the Western and Northern divisions. The stormiest winter half-year was that of 1882-83, when there were as many as 27 gales, of which 3 were severe and 3 partially severe. The quietest winter half was that of 1892-93, when there were only 7 gales, none of general, and only 1 of partial severity. In the winter six months of 1873-74 and of 1899-1900 there were no gales in the South either of general or partial severity. The stormiest summer half-years were those of 1879, 1882, and 1885, in each of which seasons there were 8 gales; in 1882 one was of general and in 1885 one was of partial severity. In the summer halves of 1874, 1875, and 1893 there was only 1 gale on our South coasts, while in the summer half of 1894 there were none at all.

The seasonal results show that of all the gales which occurred in the South, 40 per cent were experienced in the winter, 35 per cent in the autumn, 17 per cent in the spring, and 8 per cent in the summer. The proportion of winter gales was smaller than in the West and North, while the proportion of summer gales was appreciably larger than in any of the other three divisions. The stormiest winter of the series was that of 1893-94, when there were 15 gales, of which 2 were severe and 1 partially severe. The total number was, however, almost as large in the winters of 1876-77 and 1883-84, and in each of those seasons the number of severe and partially severe gales was somewhat larger than in 1893-94. The quietest winter of the series was the anticyclonic season of 1890-91, when there were only 3 gales on our South coasts, none of them either wholly or partially severe. The stormiest autumns of the series were those of 1882 and 1885, each with a total of 14 gales; the stormiest spring that of 1878, with 8 gales; and the roughest summer the memorable season of 1879, with a total of 7 gales.

The monthly means for the South coasts show that gales were most frequent in November, and more frequent in December than in January. In March the number experienced was somewhat greater than in February. The stormiest month of the 30-years period was November 1882, with a total of 10 gales. Only one of these was, however, severe, and that to a partial extent; in November 1877, January 1884, December 1891, and November 1895, the total number was far smaller than in November 1882, but in each case there were 3 gales either of general or partial severity. The mean results give June as by far the quietest month in the year, the number of gales then being less than half that

TABLE III.—NUMBER OF GALES EXPERIENCED ON THE SOUTH COASTS OF THE BRITISH ISLANDS IN EACH MONTH, IN EACH SEASON, AND IN EACH YEAR OF THE 30 YEARS 1871-1900.

YEARS.	January.			February.			March.			April.			May.			June.			July.			August.			September.			October.		
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871	1	1	...	3	...	1	3	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...
1872	8	1	...	...	...	...	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...
1873	4	...	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...
1874	2	...	...	1	...	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
1875	2	...	1	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...
1876	2	...	...	2	...	...	4	1	...	2	...	1	...	...	...	...	...	...	...	...	...	1	...	...	2	...	...	1	...	...
1877	4	1	1	2	...	...	2	...	...	1	...	1	1	...	...	1	...	1	...	...	...	1	...	...	...	...	...	1	1	...
1878	3	...	1	...	...	...	5	...	1	1	...	...	2	...	...	1	...	...	...	...	...	1	...	1	1	...	1	4	...	1
1879	3	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	4	...	...	1	...	...	1	...	...
1880	...	...	...	4	...	...	1	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...	...	4	...	...
1881	2	1	...	2	...	...	3	...	...	3	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	2	1	...
1882	3	...	...	3	...	1	2	...	...	4	1	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	2	1	...
1883	6	1	1	4	1	1	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	3	1	...	4	...	1
1884	4	1	2	4	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	1
1885	4	...	...	3	...	...	1	...	...	1	...	...	1	...	...	1	...	...	...	...	...	2	...	...	3	...	1	8	...	2
1886	7	...	...	...	...	...	4	...	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	4	1	1
1887	1	...	...	...	...	...	2	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...	1	1	...	1
1888	1	...	...	2	...	...	3	1	...	...	...	...	1	...	...	...	...	...	2	...	...	1	...	...	...	...	...	...	...	...
1889	...	...	...	3	...	1	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	...	...	...	...	4	...	...
1890	6	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...	1	...	...	1	...	...
1891	2	...	...	...	...	...	3	1	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	...	...	...	...	6	1	1
1892	1	...	...	3	...	...	2	...	1	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...	2	...	...	1	...	1
1893	1	...	...	3	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...
1894	5	...	...	3	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	1
1895	3	...	...	3	...	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	2	...	...
1896	...	...	...	...	...	...	6	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	1	1	3	1	2
1897	1	...	...	...	...	...	3	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	2	...	1	...	...	...
1898	...	...	...	2	...	...	3	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
1899	5	1	1	2	...	...	...	...	...	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...
1900	2	...	...	4	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	3	...	...	1	...	...	2	...	...
Totals	83	8	8	56	2	5	61	4	6	23	1	3	13	...	...	5	...	1	11	...	...	30	...	1	32	2	5	70	6	12
Means	2·8	0·3	0·3	1·9	0·1	0·2	2·0	0·1	0·2	0·8	...	0·1	0·4	...	...	0·2	...	...	0·4	...	...	1·0	...	...	1·1	0·1	0·2	2·3	0·2	0·4

TABLE III.—*Continued.*

Years.	November.			December.			The Seasons.												The Six Months.						The Entire Year.		
							The Spring.			The Summer.			The Autumn.			The Winter.			The Summer Half-year.			The Winter Half-year.					
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871	...	...	...	1	...	1	4	...	...	1	...	...	2	...	...	4	1	1	3	...	...	12	1	2	12	1	2
1872	6	...	3	2	1	...	4	...	...	...	...	...	10	...	3	9	1	1	3	...	...	12	1	1	24	2	3
1873	2	...	...	1	...	...	2	...	...	1	...	...	4	...	...	7	1	...	2	...	...	18	1	3	13	...	...
1874	1	...	1	3	1	1	2	...	1	...	...	...	3	...	1	4	...	...	1	...	1	8	...	...	11	1	3
1875	4	...	1	1	...	...	1	...	...	1	...	...	5	...	1	5	1	2	1	...	...	9	1	3	10	...	2
1876	1	...	...	7	2	...	6	1	1	1	...	...	4	...	...	5	...	...	5	...	1	14	1	1	22	3	1
1877	5	2	1	1	...	...	4	...	1	2	...	1	6	3	1	13	3	1	4	...	2	17	3	1	19	4	4
1878	2	1	...	1	...	1	8	...	1	2	...	1	7	1	2	4	...	1	6	...	2	15	3	3	21	1	6
1879	1	...	...	3	...	...	...	...	...	7	...	...	3	...	...	6	...	1	8	...	...	12	1	2	18	...	...
1880	5	...	1	2	...	...	2	...	1	...	...	...	11	...	1	7	...	...	3	...	...	10	...	1	19	...	2
1881	5	1	...	3	...	2	6	...	...	1	...	...	7	2	...	6	1	...	4	...	...	18	1	1	21	3	2
1882	10	...	1	1	...	...	6	1	...	2	...	...	14	1	1	9	...	3	8	1	...	18	2	3	29	2	2
1883	5	...	...	5	...	1	4	...	...	3	...	...	12	1	1	11	2	2	6	1	...	27	3	3	34	3	4
1884	2	...	...	5	2	...	2	...	...	...	...	...	6	...	1	13	1	3	3	...	...	22	1	4	21	3	3
1885	3	...	...	4	...	...	3	...	...	3	...	...	14	...	3	12	2	...	8	..	1	18	2	1	31	...	3
1886	3	...	1	6	1	1	7	...	...	...	...	...	8	1	2	11	...	...	4	...	...	26	...	2	28	2	3
1887	2	1	...	3	...	...	4	...	1	...	...	...	5	1	2	7	1	1	4	...	1	16	2	4	13	1	3
1888	8	...	...	3	...	...	4	1	...	3	...	...	8	...	...	6	...	...	4	...	...	12	2	1	21	1	...
1889	2	...	...	1	...	...	2	...	...	3	...	...	6	...	...	6	...	1	3	...	...	16	...	1	15	...	1
1890	5	...	2	1	...	...	...	...	...	4	...	...	7	...	2	7	1	1	5	...	...	13	1	1	18	1	3
1891	2	1	...	4	2	1	3	1	...	3	...	...	8	2	1	3	...	...	3	...	...	12	1	2	20	5	2
1892	...	...	...	1	...	...	2	...	1	3	...	...	3	...	1	8	2	1	5	...	...	18	4	3	13	...	2
1893	4	1	...	7	1	1	1	...	...	...	...	...	8	1	...	5	...	...	1	...	...	7	...	1	20	2	1
1894	2	2	...	3	...	...	1	...	...	...	...	...	5	2	1	15	2	1	...	...	...	23	3	1	17	3	1
1895	6	...	3	4	...	2	...	...	...	2	...	...	8	...	3	9	...	1	2	...	...	14	2	2	20	...	6
1896	2	...	...	4	...	...	7	...	2	...	...	...	8	2	3	4	...	2	4	1	1	18	...	7	19	2	5
1897	2	1	...	4	...	1	3	1	...	1	...	...	4	1	1	5	...	...	3	...	1	13	2	2	13	2	2
1898	2	...	...	3	...	...	5	...	...	...	...	...	3	...	...	6	...	1	2	...	...	11	1	1	13	...	...
1899	4	...	...	2	...	...	3	...	...	...	...	...	6	...	...	10	1	1	4	...	...	13	1	1	18	1	1
1900	2	...	...	5	1	...	1	...	...	3	...	...	5	...	...	8	...	...	5	...	...	13	...	...	20	1	...
Totals	98	10	14	91	11	12	97	5	9	46	...	2	200	18	31	225	20	25	114	3	10	455	40	58	573	44	67
Means	3·3	0·3	0·5	3·0	0·4	0·4	3·2	0·2	0·3	1·5	...	0·1	6·7	0·6	1·0	7·5	0·7	0·8	3·8	0·1	0·3	15·2	1·3	1·9	19·1	1·5	2·2

Note.—The figures under the letter S denote, in each case, the number of Severe Gales, and those under the letter P the number of Partially Severe Gales.

in July. In August the number was more than twice as large as in May, and appreciably larger even than in April.

Gales on the East Coasts.

In Table IV. the results for the East coasts are given in a similar form to that for the three other divisions. The mean annual number of gales in this district was 15·6—appreciably less than in any of the other divisions, and little more than half the number recorded in the West. The stormiest year was 1877, with a total of 26 gales, 2 of which were severe and 4 partially severe. In 1883 the total number was equally large, but none of the gales were wholly severe, and only 3 partially so. The quietest year was 1887, with a total of only 7 gales, none of them even of partial severity. 1874 and 1889 were both distinguished by an equally small number, but in the latter year 2 of the gales were partially severe, while in the former year 4 were partially and 1 generally severe.

Of the total number of gales in the East 84 per cent occurred in the winter half of the year, and 16 per cent in the summer half, the proportions being precisely the same as on the North coasts. The stormiest winter half was that of 1882-83, when there were as many as 25 gales—nearly twice the average. The number of severe and partially severe gales in that season (1 and 2 respectively) was, however, exceeded in several other years, and most notably in 1894-95, when, out of a total of 15 gales, 2 were severe and 5 partially so. The quietest winter half-year was that of 1892-93, when there were only 8 gales, none either of general or partial severity. The total number was equally small in 1872 and in 1875, but in the former year 2 of the 8 were partially severe, while in the latter year 3 were partially and 1 generally severe. The stormiest summer half-year was that of 1871, with a total of 5 gales; in 1873, 1889, and 1893 there were none at all.

The seasonal results show that of all the gales which occurred on our East coasts 39 per cent were experienced in the winter, 37 per cent in the autumn, 20 per cent in the spring, and 4 per cent in the summer. The proportion of winter gales was smaller than in any of the other divisions, but the proportion of autumn and spring gales was somewhat larger. The stormiest winter was that of 1876-77, with a total of 13 gales, 2 of them severe and 2 partially severe; in 1882-83 the total number was equally large, but only 1 of the gales was even of partial severity. The quietest winter was that of 1888-89, when there were only 2 gales, 1 being of partial severity. The stormiest autumn was in 1878, when there were 11 gales, 2 of which were generally severe. The quietest autumn occurred in 1887, when there were only 2 gales, neither of them of any severity; the total number was equally small in three other autumns, viz. those of 1874, 1897, and 1900, but in each of these cases at least 1 of the gales was either wholly or partially severe. The stormiest spring was that of 1891, with a total of 7 gales, none of them, however, of any degree of severity. In no other spring was there more than 1 severe or partially severe gale. Summer gales are, as we have seen, rare on the East coasts, though somewhat less so than in the North. The largest number, 2, occurred in 1871, 1876, 1890, 1892, 1897, and 1900; in 17 of the 30 years there were none at all.

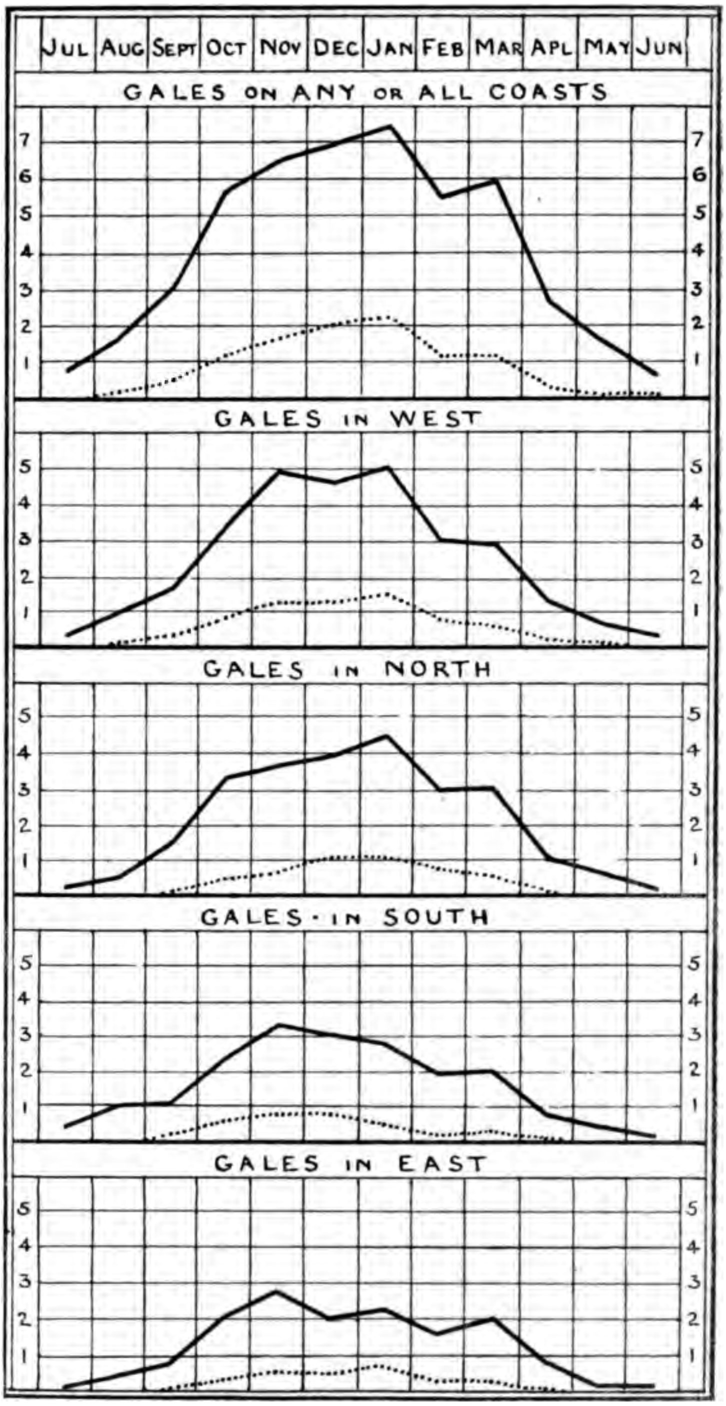


FIG. 1.—Mean Monthly Prevalence of Gales on various coasts of the British Isles during the 30 years 1871-1900. Gales of all kinds are shown by the thick lines, and Severe or Partially Severe Gales by the dotted lines.

TABLE IV.—NUMBER OF GALES EXPERIENCED ON THE EAST COASTS OF THE BRITISH ISLANDS IN EACH MONTH, IN EACH SEASON, AND IN EACH YEAR OF THE 30 YEARS 1871-1900.

YEARS.	January.			February.			March.			April.			May.			June.			July.			August.			September.			October.		
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871	1	...	1	1	1	...	1	...	...	1	...	...	...	...	...	1	...	...	...	...	...	1	...	...	2	...	...	...	...	...
1872	4	...	2	1	...	...	1	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
1873	3	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
1874	1	...	...	1	...	1	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
1875	3	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	4	...	...
1876	3	...	...	...	...	...	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	...	...	...
1877	6	2	...	2	...	...	3	...	...	2	...	1	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	2	...	1
1878	3	...	...	...	...	...	3	1	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	...	3	...	...
1879	2	...	...	...	...	...	3	...	...	1	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
1880	...	...	...	3	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	4	1	...
1881	2	...	1	2	...	...	3	...	1	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	4	1	...
1882	2	...	1	1	...	...	1	...	...	2	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	2	1	...
1883	5	...	1	6	...	...	4	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	3	...	...
1884	2	1	1	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...
1885	4	...	...	3	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	5	...	...
1886	1	...	...	...	...	...	3	...	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	...
1887	...	...	...	...	...	...	2	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...
1888	1	...	...	2	...	...	4	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1889	...	...	...	2	...	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...
1890	5	...	3	...	...	...	1	...	...	1	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	3	...	...
1891	...	...	...	1	...	...	6	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	1	4	...	2
1892	1	...	...	4	...	...	1	...	...	1	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	4	...	...
1893	1	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1894	4	...	1	4	1	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
1895	5	1	2	1	...	...	2	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
1896	1	...	...	...	...	...	4	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...	1	3	...	1
1897	3	1	1	2	...	...	5	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	1	...	...	...	...	...
1898	1	...	...	2	...	1	3	...	1	...	...	...	2	...	...	...	...	...	...	...	...	1	...	...	...	...	...	2	...	...
1899	3	1	...	2	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...
1900	1	...	...	4	1	1	3	...	...	2	...	1	...	...	...	...	...	...	...	...	...	2	...	1	...	...	...	1	...	1
Totals	68	6	16	52	3	6	63	2	7	24	1	3	7	...	...	5	...	...	3	...	...	11	...	1	23	...	2	62	3	6
Means	2·3	0·2	0·5	1·7	0·1	0·2	2·1	0·1	0·2	0·8	...	0·1	0·2	...	...	0·2	...	...	0·1	...	...	0·4	...	...	0·8	...	0·1	2·1	0·1	0·2

TABLE IV.—*Continued.*

Years.	November.			December.			The Seasons.												The Six Months.						The Entire Year.		
							The Spring.			The Summer.			The Autumn.			The Winter.			The Summer Half-year.			The Winter Half-year.					
	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.
1871 . . .	2	...	...	...	...	...	2	...	...	2	...	...	4	...	...	5	2	2	5	...	...	9	2	3	10	1	1
1872 . . .	6	...	2	2	...	...	4	...	...	...	...	...	8	...	2	5	...	2	3	...	...	8	...	2	19	...	4
1873 . . .	4	...	1	1	...	1	1	...	...	...	...	...	5	...	1	6	...	1	...	...	...	15	...	3	11	...	3
1874 . . .	1	1	...	1	...	1	2	...	1	...	...	...	2	1	1	3	...	2	1	...	1	9	...	3	7	1	4
1875 . . .	3	1	1	1	...	...	1	...	...	...	...	...	9	1	1	5	...	2	2	...	...	8	1	3	15	1	2
1876 . . .	3	...	1	5	...	2	4	1	...	2	...	...	5	...	1	4	...	...	4	...	...	15	2	1	19	1	3
1877 . . .	6	...	2	3	...	...	5	...	1	1	...	...	9	...	3	13	2	2	4	...	1	19	2	3	26	2	4
1878 . . .	6	2	...	1	...	...	4	1	...	1	...	...	11	2	...	6	...	...	4	...	...	17	1	3	20	3	...
1879 . . .	3	...	...	2	...	...	4	...	...	1	...	...	3	...	...	3	...	...	2	...	...	15	2	...	12	...	...
1880 . . .	2	...	...	...	...	...	2	...	...	...	...	...	7	1	...	5	...	1	2	...	...	9	...	1	12	1	1
1881 . . .	2	...	...	2	...	...	5	...	1	1	...	...	7	1	...	4	...	1	4	...	...	13	1	2	19	1	2
1882 . . .	6	...	...	2	...	...	3	1	...	1	...	...	8	1	...	5	...	1	3	1	...	12	1	1	17	2	1
1883 . . .	2	...	...	4	...	1	4	...	1	...	...	...	7	...	...	13	...	1	2	...	...	25	1	2	26	...	3
1884 . . .	1	...	1	3	...	...	...	...	...	...	...	...	5	...	1	9	1	2	1	...	...	14	1	2	13	1	2
1885 . . .	1	...	...	2	...	...	1	...	...	...	...	...	7	...	...	10	...	...	2	...	...	14	...	1	17	...	...
1886 . . .	2	...	...	4	1	...	5	...	1	...	...	...	6	...	...	3	...	...	3	...	...	12	...	1	16	1	1
1887 . . .	1	...	...	1	...	...	4	...	...	...	...	...	2	...	...	4	1	...	3	...	...	11	1	...	7	...	...
1888 . . .	9	...	1	...	...	...	5	...	...	...	...	...	9	...	1	4	...	...	1	...	...	9	...	...	17	...	1
1889 . . .	1	...	...	...	...	...	1	...	1	...	...	...	4	...	...	2	...	1	...	...	...	12	...	3	7	...	2
1890 . . .	3	...	...	2	...	...	2	...	...	2	...	...	6	...	...	5	...	3	3	...	...	10	...	3	17	...	3
1891 . . .	2	...	...	3	1	...	7	...	...	1	...	...	7	...	3	3	...	...	3	...	1	15	...	...	19	1	3
1892 . . .	...	...	...	...	...	...	2	...	...	2	...	...	4	...	...	8	1	...	3	...	...	15	1	2	13	...	...
1893 . . .	4	1	...	4	...	1	...	...	...	...	...	...	4	1	...	4	...	...	...	...	...	8	...	...	12	1	1
1894 . . .	2	...	1	3	1	1	1	...	...	...	...	...	4	...	1	12	1	3	1	...	...	16	2	3	16	2	4
1895 . . .	5	...	2	5	...	3	3	...	1	...	...	...	7	...	2	9	2	3	1	...	...	15	2	5	21	1	8
1896 . . .	1	...	...	1	...	...	5	...	1	...	...	...	6	...	2	6	...	3	3	...	1	17	...	6	13	...	3
1897 . . .	1	1	...	2	...	...	5	...	...	2	...	...	2	1	...	6	1	1	3	...	...	15	1	2	16	2	1
1898 . . .	3	...	...	3	...	2	5	...	1	1	...	...	5	...	...	5	...	1	3	...	...	9	1	2	17	...	4
1899 . . .	4	...	...	3	...	...	2	...	...	...	...	...	7	...	...	8	1	2	3	...	...	14	1	2	17	1	...
1900 . . .	1	...	...	3	...	1	5	...	1	2	...	1	2	...	1	8	1	1	4	...	2	16	1	1	17	1	5
Totals . . .	87	6	12	63	3	13	94	3	10	19	...	1	172	9	20	183	13	35	73	1	6	396	24	60	468	24	66
Means . . .	2·9	0·2	0·4	2·1	0·1	0·4	3·1	0·1	0·3	0·6	...	...	5·7	0·3	0·7	6·1	0·4	1·2	2·4	...	0·2	13·2	0·8	2·0	15·6	0·8	2·2

Note.—The figures under the letter S denote, in each case, the number of Severe Gales, and those under the letter P the number of Partially Severe Gales.

The monthly means for the East coasts show that gales were most frequent in November, next to this in January, and next to this in March, October, and December, the results for the three months last mentioned being precisely similar. The stormiest month in the whole 30 years was November 1888, with a total of 9 gales, only one, however, of partial severity. On an average, July was the quietest month, the number of gales recorded being, however, only slightly less than in June. August was far more stormy than May, and September about equal in that respect to April.

In Fig. 1 the monthly means for the four divisions are shown graphically, and in order that these may be compared not only with each other but with the general results for the entire kingdom, I have reproduced at the top of the diagram the curves given in my former paper. These latter show the monthly gale prevalence, quite irrespective of the extent or position of coast affected.

As regards the West coast gales, it will be seen that while the actual maximum occurs in January, the mean number then is very slightly higher than in November, the tendency for stormy weather in both months being somewhat more pronounced than in December. On the North coasts the maximum occurs in January, and is very clearly marked. On the South and East coasts it occurs in November; in the former district January is less stormy than December, but in the latter it is more so. On our East coasts gales are more frequent in March than in February, but in the three other divisions the mean number in the two months is almost precisely the same.

The dotted curves giving the mean monthly prevalence of severe or partially severe gales, show that in the West, and also in the East, the maximum occurs in January, and in the North in January and December, the average in each month being identical. In the South the maximum occurs in November and December.

Prevalence of Gales at Different Times in the Year, as shown by Five-Day Means.

Fig. 2 gives for each quadrant the prevalence of gales at different times in the year, as shown by five-day means. In this case we have again reproduced at the head of the diagram the results for the whole of the United Kingdom, as given in the former paper. In each section of the diagram the thin curve has been drawn from the actual data, while the thick black curve represents the same values, smoothed by the application of the usual formula $B = \frac{A + 2B + C}{4}$. In the following remarks we deal chiefly with the smoothed results, from which purely accidental features may be fairly said to have been wholly or partly eliminated.

On the West coasts the actual maximum of gale prevalence occurs at two different times in the year, once in the five-day period, November 12-16, and again in the periods December 27-31 and January 1-5. The tendency for stormy weather in the latter periods is not confined to our Western coasts. Over the United Kingdom generally a quiet spell just before Christmas is usually followed by stormy weather, which sets in shortly after that festival and continues until the new year has fairly opened. Other features of interest shown in the curve of gale prevalence

for the Western division are a well-marked maximum towards the close of August, a less clearly marked one at the end of February, and a very pronounced maximum at the end of March. The stormy period in August is equally well shown in the curves for the South coast, but is far less evident in those for the North and East coasts. The gales which occur so frequently at about that time are due, as a rule, to cyclonic systems, which advance directly over the United Kingdom, the barometer being previously high to the southward and low to the northward of these islands. Summer storm systems are less deep than those we so

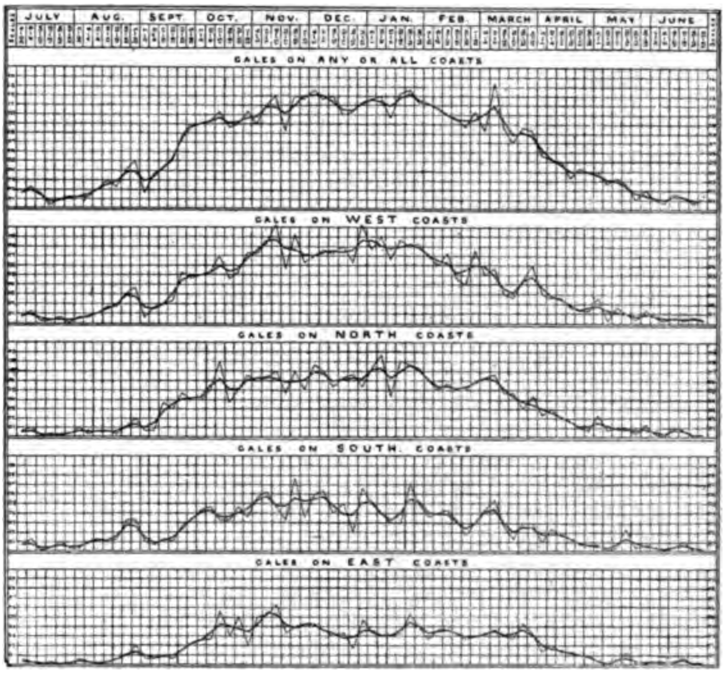


Fig. 2.—Prevalence of Gales on various coasts of the British Isles at different times in the year, as shown by Five-Day Means. The thin curves have been drawn from the actual data, and the thick curves from the smooth values.

often get in the winter time, and in these August gales the barometric minimum, though sufficiently low to produce steep Westerly gradients over the Southern portions of the United Kingdom, is seldom so low as to cause any serious increase in the Easterly and South-easterly gradients on our Northern and Eastern coasts. In the Western division the curve of gale prevalence in June and July is, as a rule, singularly flat, but at the beginning of July there is usually some tendency for the weather to become rough and unsettled.

On the North coasts the maximum of gale prevalence occurs in the five-day period, January 21-25, secondary maxima being shown in the early parts both of that month and of December. Other features of interest in this curve are a decided tendency for stormy weather about the middle of October (shown in a lesser degree in some of the other

districts), and a similar tendency at the beginning of March, the latter feature being prevalent also in the West and South, but not in the East. As regards the summer months, there appears to be some little tendency for the weather in the North to become stormy about the middle of June and also at the end of August. The August maximum is, however, far less strongly marked in the North than in the West and South.

In the winter months the curve of gale prevalence for the South coasts presents a very irregular aspect, and suggests grave doubts as to whether in this matter a 30-year period is sufficiently long to yield means of absolute reliability. The actual maximum for the year occurs in the five-day period November 7-11, but subsidiary maxima of almost equal intensity are recorded at precisely the same time in December and in the period January 21-25. The continuance of a high level of gale frequency in the three weeks beginning with November 22 seems to show that on our South coasts that time in the year is, upon the whole, the stormiest—a feature not present to any appreciable extent in the other three divisions. The tendency for stormy weather in the early part of March is far more pronounced in the South than in any other division. The portion of the curve relating to the summer months presents features of greater interest than that shown in the other districts. There is, in the first place, a decided maximum about the middle of May, and some tendency for stormy weather about the middle of June. July is, however, upon the whole rougher than June, while the tendency for stormy weather at the close of August is here present in a very marked degree, the maximum at this time being followed by a decided minimum in the early part of September.

On our East coasts the maximum of gale frequency is very pronounced, and occurs in the five-day period November 7-11, the succeeding five days being, however, almost as stormy. Secondary maxima far below the actual one occur in the periods October 13-17 and January 21-25, the close of November and the beginning of December being also a rather stormy time. The other portions of the East coast curve present few features of interest. March is a rather rough month, especially in the closing part, while there is, as in the South, some tendency for stormy weather about the middle of May. As we have before remarked, the gales which so often spring up in the West and South at the close of August seldom extend to the East or North coasts, the contrast between the appearance of the two pairs of curves at this time in the year being very striking.

In all districts, and throughout nearly the whole year, there appears to be a marked tendency for the weather to assume a quieter aspect about the middle of each month than it wears at the beginning or end. The fact is a curious one, and admits, so far as we are aware, of no scientific explanation.

Direction of Wind in Gales.

Tables V. to VIII. give in percentage form, and for each of the four divisions, the general direction from which gales have blown in each of the 30 years, together with means for the entire period. The gales have been grouped under the eight chief points of the compass, but the figures have also been combined to show, firstly, the proportion of gales from

each of the quadrants more commonly represented, and secondly, the proportion of gales respectively from Arctic, or polar, and from Atlantic, or equatorial, directions. A column is also given showing the proportion of "vortical" gales, the term applying to those cases in which the centre of a storm system advanced directly over the coast in question, and in which the gale consequently blew from various quarters.

TABLE V.—DIRECTIONS FROM WHICH GALES BLEW ON THE WEST COASTS OF THE BRITISH ISLANDS DURING EACH OF THE 30 YEARS 1871-1900.

YEARS.	PERCENTAGE OF GALES FROM								Vortical Gales.	PERCENTAGE OF GALES FROM					
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W.	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial, Directions, S.E., S., S.W., and W.
1871	3	...	7	16	29	25	8	12	...	3	23	54	20	22	78
1872	5	3	...	10	34	40	3	5	...	8	10	74	8	13	87
1873	2	4	6	4	20	31	12	21	...	6	10	51	33	33	67
1874	...	...	...	7	23	24	23	7	16	...	7	47	30	7	77
1875	1	...	9	9	30	17	16	9	9	1	18	47	25	19	72
1876	7	...	9	11	15	22	16	13	7	7	20	37	29	29	64
1877	6	1	9	7	24	26	9	16	2	7	16	50	25	32	66
1878	12	10	4	10	10	22	11	21	...	22	14	32	32	47	53
1879	2	5	5	16	15	29	14	10	4	7	21	44	24	22	74
1880	...	4	4	5	29	40	7	4	7	4	9	69	11	12	81
1881	...	...	12	16	27	23	10	5	7	...	28	50	15	17	76
1882	4	4	1	6	12	29	13	14	17	8	7	41	27	23	60
1883	5	1	5	10	22	18	19	12	8	6	15	40	31	23	69
1884	6	4	...	2	19	39	18	12	...	10	2	58	30	22	78
1885	5	...	...	9	29	40	8	9	...	5	9	69	17	14	86
1886	6	4	2	5	20	39	15	6	3	10	7	59	21	18	79
1887	...	...	...	8	21	40	12	14	5	...	8	61	26	14	81
1888	5	5	8	13	14	24	15	10	6	10	21	38	25	28	66
1889	13	3	...	...	10	25	18	24	7	16	...	35	42	40	53
1890	7	...	3	8	26	20	15	16	5	7	11	46	31	26	69
1891	1	...	...	6	21	21	19	14	18	1	6	42	33	15	67
1892	9	5	9	18	6	11	16	22	4	14	27	17	38	45	51
1893	15	2	4	5	10	26	14	17	7	17	9	36	31	38	55
1894	1	...	3	11	18	23	26	15	3	1	14	41	41	19	78
1895	8	6	6	17	7	16	19	17	4	14	23	23	36	37	59
1896	1	...	...	6	6	19	20	34	14	1	6	25	54	35	51
1897	4	4	3	10	21	29	11	15	3	8	13	50	26	26	71
1898	7	5	7	7	11	19	14	19	11	12	14	30	33	38	51
1899	...	4	3	7	15	29	19	20	3	4	10	44	39	27	70
1900	9	4	1	4	13	25	19	20	5	13	5	38	39	34	61
Means	4·8	2·6	4·0	8·8	18·8	26·0	14·8	14·3	5·9	7·4	12·8	44·8	29·1	25·7	68·4

The mean results given in Table V. show that on the West coasts about 68 per cent of the gales blew from Atlantic, or equatorial, directions, and about 26 per cent from Arctic, or polar, directions, the remaining 6 per cent consisting of vortical gales, or gales in which the cyclonic circulation was more or less complete. In 1872 the proportion of equatorial gales was as high as 87 per cent, and in 1885 it was as high as 86 per cent, but in 1892 and 1898 only 51 per cent of the storms blew from those directions. Vortical gales were most numerous in 1891, the proportion being then as high as 18, but were nearly as

common in 1874 and 1882, in which years the percentage values were respectively 16 and 17. In 6 of the years, viz. 1871, 1872, 1873, 1878, 1884, and 1885, none of the gales partook of this character. From the more detailed division into quadrants we see that about 45 per cent of the gales in the West blew from South or South-west, and 29 per cent from West or North-west, but only 13 per cent from East or South-east,

TABLE VI.—Directions from which Gales blew on the NORTH COASTS of the British Islands during each of the 30 Years 1871-1900.

Years.	Percentage of Gales from								Vortical Gales.	Percentage of Gales from					
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W.	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial, Directions, S.E., S., S.W., and W.
1871	7	2	5	15	21	26	17	7	...	9	20	47	24	21	79
1872	9	2	4	21	22	24	8	10	...	11	25	46	18	25	75
1873	...	...	...	5	28	21	31	15	...	...	5	49	46	15	85
1874	3	1	4	7	16	26	23	16	4	4	11	42	39	24	72
1875	7	5	14	14	14	15	17	14	...	12	28	29	31	40	60
1876	6	4	9	16	9	14	17	18	7	10	25	23	35	37	56
1877	5	3	9	13	18	16	12	22	2	8	22	34	34	39	59
1878	18	10	...	9	9	20	16	18	...	28	9	29	34	46	54
1879	6	1	...	18	16	23	18	9	9	7	18	39	27	16	75
1880	...	10	3	12	16	19	24	16	...	10	15	35	40	29	71
1881	3	9	5	18	29	11	15	10	...	12	23	40	25	27	73
1882	5	...	6	13	18	17	22	15	4	5	19	35	37	26	70
1883	5	5	4	15	27	7	17	12	8	10	19	34	29	26	66
1884	2	4	...	2	21	38	13	12	8	6	2	59	25	18	74
1885	3	2	...	13	21	25	17	9	10	5	13	46	26	14	76
1886	9	8	5	12	15	22	18	6	5	17	17	37	24	28	67
1887	7	...	...	10	22	38	8	9	6	7	10	60	17	16	78
1888	4	3	14	19	8	17	19	16	...	7	33	25	35	37	63
1889	10	3	...	...	13	7	7	40	20	13	...	20	47	53	27
1890	5	2	...	5	21	20	17	24	6	7	5	41	41	31	63
1891	4	2	4	7	25	20	16	10	12	6	11	45	26	20	68
1892	17	8	6	7	9	19	13	21	...	25	13	28	34	52	48
1893	17	3	2	3	10	20	17	20	8	20	5	30	37	42	50
1894	7	4	1	10	19	16	23	17	3	11	11	35	40	29	68
1895	12	6	8	12	12	17	11	17	5	18	20	29	28	43	52
1896	6	7	1	15	14	16	17	19	5	13	16	30	36	33	62
1897	9	5	5	19	13	21	14	14	...	14	24	34	28	33	67
1898	2	4	5	8	14	28	24	11	4	6	13	42	35	22	74
1899	2	4	4	8	21	18	18	21	4	6	12	39	39	31	65
1900	1	7	7	9	17	23	19	14	3	8	16	40	33	29	68
Means	6·1	4·3	4·3	11·3	17·6	19·6	17·2	15·3	4·3	10·4	15·6	37·2	32·5	30·0	65·7

and only 7 per cent from North or North-east. A still closer subdivision shows that as many as 26 per cent blew from South-west, an additional 19 per cent from South, and about 15 per cent from West. Less than 5 per cent were from the Northward, only 4 per cent from the Eastward, and less than 3 per cent from the North-eastward. In 11 of the 30 years there were no North-easterly gales on our Western coasts.

The mean results for the North coasts, given in Table VI., show that about 66 per cent of the gales which visited that part of the country blew from some equatorial direction, and 30 per cent from polar quarters, the

remaining 4 per cent consisting of storms of a vortical character. The proportion of equatorial gales was somewhat smaller, and the proportion of polar gales consequently larger, than in the Western division. Atlantic, or equatorial, gales reached their highest proportion, 85 per cent, in 1873, no other year showing a higher percentage than 79. The smallest proportion by far of equatorial gales was in 1889, when the percentage was as low as

TABLE VII.—Directions from which Gales blew on the SOUTH COASTS of the British Islands during each of the 30 Years 1871-1900.

Years.	Percentage of Gales from								Vortical Gales.	Percentage of Gales from					
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W.	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial, Directions, S.E., S., S.W., and W.
1871	4	...	...	8	4	58	15	11	...	4	8	62	26	15	85
1872	2	2	2	...	19	62	6	7	...	4	2	81	13	13	87
1873	...	6	10	7	12	33	25	7	...	6	17	45	32	23	77
1874	...	9	...	...	9	39	26	17	...	9	...	48	43	26	74
1875	3	...	10	...	...	43	32	12	...	3	10	43	44	25	75
1876	2	3	9	7	8	43	18	10	...	5	16	51	28	24	76
1877	5	8	5	3	15	38	11	15	...	13	8	53	26	33	67
1878	5	5	2	2	...	51	14	21	...	10	4	51	35	33	67
1879	...	3	22	3	11	32	24	5	...	3	25	43	29	30	70
1880	...	8	18	4	6	53	9	2	...	8	22	59	11	28	72
1881	...	12	17	6	7	39	14	5	...	12	23	46	19	34	66
1882	4	6	2	...	2	37	30	16	3	10	2	39	46	28	69
1883	6	4	6	...	18	27	28	11	...	10	6	45	39	27	73
1884	2	12	3	...	7	42	25	9	...	14	3	49	34	26	74
1885	4	5	11	1	7	41	20	4	7	9	12	48	24	24	69
1886	2	5	7	2	7	49	20	4	4	7	9	56	24	18	78
1887	8	8	...	...	22	38	19	5	...	16	...	60	24	21	79
1888	2	12	5	9	9	32	23	8	...	14	14	41	31	27	73
1889	6	9	3	...	7	28	32	15	...	15	3	35	47	33	67
1890	...	3	8	...	5	35	32	17	...	3	8	40	49	28	72
1891	...	...	10	2	19	29	38	2	...	...	12	48	40	12	88
1892	4	...	19	4	...	24	25	24	...	4	23	24	49	47	53
1893	5	2	3	2	17	36	21	4	10	7	5	53	25	14	76
1894	...	3	3	2	7	35	36	8	6	3	5	42	44	14	80
1895	3	3	15	12	9	23	21	14	...	6	27	32	35	35	65
1896	3	2	7	4	7	17	31	13	16	5	11	24	44	25	59
1897	4	4	...	...	6	40	40	6	...	8	...	46	46	14	86
1898	4	27	8	...	8	19	19	7	8	31	8	27	26	46	46
1899	...	...	...	6	10	28	44	12	...	...	6	38	56	12	88
1900	5	8	5	4	9	24	22	13	10	13	9	33	35	31	59
Means	2·8	5·5	7·1	2·8	9·2	36·8	23·7	9·8	2·3	8·3	9·9	46·0	33·5	25·2	72·5

27; 53 per cent of the storms in this year (a very quiet one) were from polar quarters, while no fewer than 20 per cent were classed as "vortical." The division of winds into quadrants shows that 37 per cent of the gales in the North blow from South or South-west, nearly 33 per cent from West or North-west, nearly 16 per cent from East or South-east, and about 10 per cent from North or North-east. The closer subdivision into 8 points shows that about 20 per cent blew from South-west alone, 18 per cent from South, 17 per cent from West, and 15 per cent from North-

west; 6 per cent were from the Northward, and only 4 per cent from each of the quarters North-east and East.

From Table VII. we see that 73 per cent of the gales in the South were from some equatorial direction, and 25 per cent from polar quarters, little more than 2 per cent being of a vortical character. The proportion of equatorial gales was largest (88 per cent) in the two years 1891 and 1899, but was nearly as large in 1872. It was smallest (46 per cent) in 1898, an equal proportion of gales in that year being from polar quarters, and the remaining 8 per cent of a vortical character. The division into quadrants shows that 46 per cent of the gales in the South blew from South or South-west, 34 per cent from West or North-west, 10 per cent from East or South-east, and 8 per cent from North or North-east. Referred to the 8 principal points of the compass we see that nearly 37 per cent of the gales were from the South-westward alone, and nearly 24 per cent from the Westward. The distribution of the remainder was more equal than in the case of the Western and Northern divisions. About ten per cent were from North-west, 7 per cent from East, and 6 per cent from North-east, but less than 3 per cent from North or from South-east, the prevalence of gales from the two latter directions being much smaller in the South than in any other part of the kingdom. The rarity of Northerly gales is probably due in a large measure to the fact that on our South coasts winds from that quarter blow from off shore. It has often been noticed that with a steep Northerly gradient the wind force at our own Southern stations has not been given as more than 6 or 7, while observers on the French coasts have reported a force of 8 or 9. We must not therefore assume that in the Channel Northerly gales are as rare as the figures would lead one to imagine. The singular infrequency of gales from the South-eastward is a fact less easily explained. An examination of a large number of weather-charts seems, however, to show that in very many instances when a deep cyclonic system arrives off our South-west coasts the barometric gradient becomes steep in the West and North, and also in the East. In the South the isobars tend to widen out; and although the wind may increase to gale force at the mouth of the Channel on the one hand, and on the Norfolk and Suffolk coasts on the other, nothing more than a fresh or strong breeze is felt in the intervening districts. The issue of warnings to the Channel coasts for a South-easterly gale would appear to be an operation attended by much risk.

The results for the East coasts, given in Table VIII., show that less than 53 per cent of the gales in that division blew from equatorial directions, while more than 44 per cent were from polar quarters, the proportions differing widely from those existing on any other of the three coasts. The proportion of equatorial gales was greatest, by far, in 1874, the percentage being then as high as 86; in no other year was it higher than 73. The percentage value was extremely low (only 13) in 1879, the proportion of polar gales in that very inclement year being as high as 79 per cent. The division into quadrants shows that on our East coasts the gales blew from widely divergent quarters. A slight preponderance (nearly 28 per cent) were from the commonly prevailing quarters South or South-west, but nearly 25 per cent were from East or South-east, more than 22 per cent from West or North-west, and nearly

22 per cent from North or North-east. In 1879 half the gales experienced were from East or South-east. Referred to the eight principal points, we find that in this, as in all other districts, the highest proportion of gales (nearly 19 per cent) was from South-west. Nearly 14 per cent were, however, from North-east, and more than 13 per cent from East and also from West, while nearly 12 per cent were from South-

TABLE VIII.—Directions from which Gales blew on the EAST COASTS of the British Islands during each of the 30 Years 1871-1900.

Years.	Percentage of Gales from								Vortical Gales.	Percentage of Gales from					
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W.	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial, Directions, S.E., S., S.W., and W.
1871	23	14	18	15	10	9	8	3	...	37	33	19	11	58	42
1872	11	18	...	21	7	23	4	11	5	29	21	30	15	40	55
1873	...	4	21	12	9	23	27	4	...	4	33	32	31	29	71
1874	...	14	...	29	...	21	36	...	...	14	29	21	36	14	86
1875	6	7	27	13	10	18	13	6	...	13	40	28	19	46	54
1876	7	9	25	19	11	19	7	3	...	16	44	30	10	44	56
1877	10	12	13	9	14	16	7	15	4	22	22	30	22	50	46
1878	12	30	8	3	2	25	5	15	...	42	11	27	20	65	35
1879	11	8	46	4	...	3	6	14	8	19	50	3	20	79	13
1880	...	24	24	19	8	13	4	...	8	24	43	21	4	48	44
1881	5	15	28	9	12	17	6	8	...	20	37	29	14	56	44
1882	6	20	12	9	...	20	15	6	12	26	21	20	21	44	44
1883	19	6	6	14	20	13	17	5	...	25	20	33	22	36	64
1884	11	15	...	8	8	23	27	8	...	26	8	31	35	34	66
1885	18	15	17	3	15	20	6	6	...	33	20	35	12	56	44
1886	3	10	11	8	9	27	11	2	19	13	19	36	13	26	55
1887	4	19	...	...	14	21	22	6	14	23	...	35	28	29	57
1888	3	25	13	22	2	26	6	3	...	28	35	28	9	44	56
1889	12	20	7	14	...	7	7	33	...	32	21	7	40	72	28
1890	9	3	16	2	13	19	19	19	...	12	18	32	38	47	53
1891	3	5	8	17	10	21	20	16	...	8	25	31	36	32	68
1892	15	12	27	15	4	6	11	10	...	27	42	10	21	64	36
1893	8	17	13	13	29	...	4	8	8	25	26	29	12	46	46
1894	10	3	10	6	9	30	21	5	6	13	16	39	26	28	66
1895	9	16	14	7	7	17	17	13	...	25	21	24	30	52	48
1896	4	15	4	10	6	27	17	17	...	19	14	33	34	40	60
1897	3	6	10	11	8	24	19	19	...	9	21	32	38	38	62
1898	3	34	8	8	3	18	20	6	...	37	16	21	26	51	49
1899	...	2	8	13	13	28	19	5	12	2	21	41	24	15	73
1900	9	15	12	18	5	10	13	12	6	24	30	15	25	48	46
Means	8·1	13·5	13·4	11·5	9·1	18·7	13·2	9·3	3·2	21·6	24·9	27·8	22·5	44·3	52·5

east. The smallest proportion of all blew from North, but even in this case the percentage was higher than in any other district.

The results given in these four tables suggest questions of a very wide nature as to the causes which regulate the general drift of the atmospheric currents over long periods of time. The figures refer, it is true, only to winds blowing with the force of a gale, but there are no reasons for supposing that the general directions at these times differ materially from those at other times when the air is less disturbed. The statistics give, in fact, a fairly accurate idea as to the prevailing wind

directions in the various years, and those we know are governed by the general distribution of barometrical pressure. How widely then must this have differed in the case of two years, in one of which (we quote, for sake of example, the East coast values) 86 per cent of the winds reaching gale force were from equatorial directions, while in the other only 13 per cent were of similar origin! Sometimes, as the figures show, the tendency for gales from polar or equatorial quarters extended over much longer periods than a twelvemonth, the proportion in two or even three succeeding years being largely in excess of the 30-year average. A solution of the causes which lead to those prolonged weather tendencies is scarcely likely to be achieved without an immense amount of labour on the part of investigators fully equipped with a perfect armoury of meteorological and general scientific attainments. The practical value of any successful inquiry of the kind would, however, be no mean reward for the time expended.

In Fig. 3 the direction from which gales blow in the various divisions is shown graphically by wind roses. The figures enclosed within each of the inner circles give the percentage of "vortical" gales, while the thick lines pointing towards these circles show the proportion of gales from each of the eight principal points of the compass. The length of these thick lines is determined by the outer circles, each of which, counting from the inner one, represents a proportion of 5 per cent.

The striking preponderance of gales from the South-westward on our Southern coasts at once arrests our attention, a less striking prevalence being also shown in the West. In the North there is, it will be seen, no very material difference between the percentage values for any direction between South and North-west, while in the East the gales blow with great impartiality from almost every point of the compass. In the South a gale from the Southward is less common than on any other coast excepting the East, while a gale from the South-east is, as we have before remarked, extremely rare.

An explanation of the various features shown by these wind roses is afforded by Fig. 4, giving the tracks ordinarily pursued by cyclonic disturbances which pass over or in the immediate neighbourhood of these islands. The relative frequency of the various tracks is shown by the breadth of the lines, each single percentage being represented by one hundredth of an inch. The values employed in drawing this map are those given in my former paper[1] under the section "Regions traversed by the Centres of Important Storm Systems."

The undue preponderance of gales from South-west and West on our Southern coasts is at once accounted for by the fact (doubtless a very familiar one) that the vast bulk of the storm systems move along either in an Easterly or a North-easterly direction over the more Northern parts of our area, and that we, in the South, get the winds blowing round their Southern or South-eastern sides. In the West many of the gales from South and South-west are due to cyclonic areas moving along in the directions shown by the storm tracks marked A and B, these disturbances being in very many cases too remote to cause any serious increase of wind in the South and East. In the North a gale is also caused very frequently by these two sets of storm systems, while in the rear of Class A it is not

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxviii. p. 145.

unusual for a gale to spring up from West or even North-west. The relative frequency of gales from these latter directions in the North is also partially accounted for by disturbances moving in the tracks marked

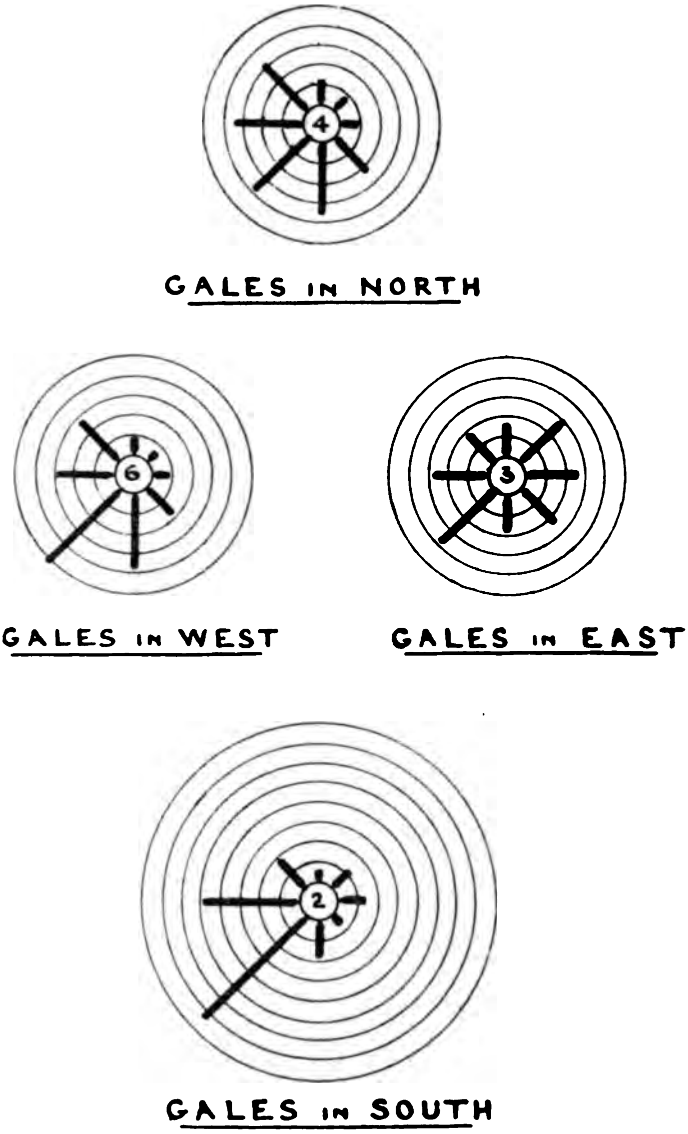


FIG. 3.—Relative Frequency of Gales on various coasts of the British Isles, from different points of the compass.

C and D; the latter must, however, be very large and deep to affect our own coasts at all seriously. In the North, and to a limited extent in the East also, storm systems moving along in the tracks marked E and F will,

if of sufficient depth, cause gales from the South-eastward, and, as these two types are not uncommon, we see at once that the percentage of gales from that quarter on the coasts mentioned is somewhat large. The high percentage of gales on our East coasts from some Easterly direction (South-east to North-east) is accounted for, but only partially, by cyclonic

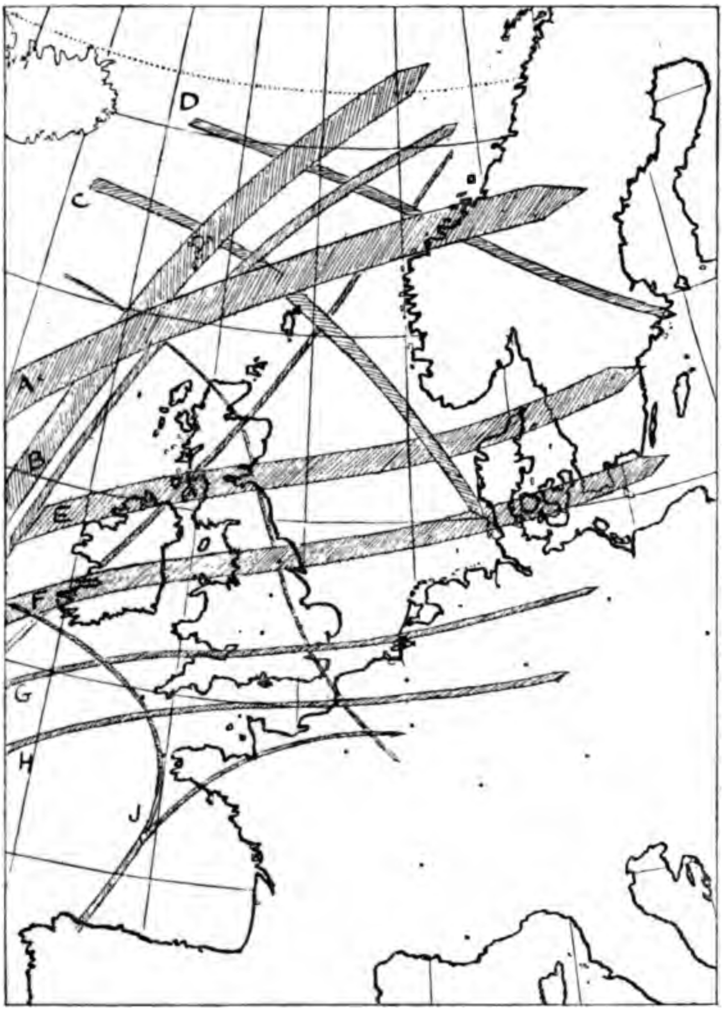


FIG. 4.—Tracks ordinarily pursued by Storm Centres appearing over various parts of North-Western Europe. (The relative frequency of each track is shown by the thickness of the shaded line.)

systems travelling in the somewhat rare tracks marked G, H, and J. Many of the Easterly gales both on this and on our Southern coasts are, however, caused by storm systems the centres of which fail to come anywhere near our islands. It is not unusual for a cyclonic area which appears over Spain, or even over the Mediterranean, to remain almost

stationary for some time but to spread out laterally in a Northerly direction, the surging process resulting in a gradual increase in the Easterly gradient over our own Southern and Eastern districts. Another, but rarer, type of gale which blows from the Eastward or North-eastward is due to cyclonic systems surging Westwards and North-westwards from Central Europe; in some cases the centres actually move out in this direction to the neighbourhood of our own Eastern and Southern coasts, but these instances are so infrequent that I have omitted them altogether from the map of storm tracks.

The high proportion of "vortical" gales on the West coasts is due very largely to the fact that the district in question covers a wide range of latitude, some 350 miles from North to South, and the possibilities of a storm centre moving Eastwards or North-eastwards over the more central parts of the district and causing a complete cyclonic circulation are therefore great. Next to the West coasts, "vortical" gales are most common in the North and East, these being due respectively to storms moving in the tracks E and F. In the Southern district the range of latitude embraced is very small, and as very few storm centres move across it in a due Easterly, and scarcely any in a due Northerly or Southerly direction, the gales experienced there are seldom of a vortical character.

DISCUSSION.

The President (Capt. D. Wilson-Barker) expressed the thanks of the Fellows to Mr. Brodie for his valuable paper and for the great trouble involved in its preparation. He thought the subject one of much interest, and that it had been treated by the author in a very satisfactory manner.

Mr. R. H. Scott remarked that he well knew the labour entailed in the preparation of such a paper, as he had himself worked upon the subject. While at the Meteorological Office he had made a record of every storm experienced in the British Isles since 1870, and had found that one very pronounced condition was that March was the only month which did not escape gales. Other months, from February to October, were liable to spells of calm weather, but March had always one or more gales. He was glad to find that Mr. Brodie's tables proved that the old idea of "Equinoctial Gales" was groundless, and that they did not exist as a constant occurrence.

Mr. C. Harding said that the paper gave ample material for making comparison with other elements. It was especially interesting to trace the relationship between barometric pressure and wind. It did not necessarily follow that the stormiest month had the isobaric lines lying most closely together; but generally in the month when storms were most frequent, the variations and range of pressure were very marked. In the stormy winter of 1893-94 this feature was most pronounced. The past winter (October to March) was one of great interest, it being, with one exception, the warmest for sixty years. This was probably due to a persistent low-pressure area in the west. In March, Easterly winds were entirely absent, while Westerly and South-westerly winds were very numerous; it was sometimes interesting to find how our expectations were turned topsy-turvy. In the cold and snowy month of January 1881, on examining the isobars, the low-pressure area was found low down in the Atlantic, and the high-pressure in the North, where the low is generally observed. Easterly winds were persistent in that month.

Mr. W. H. Dines said that he thought the Society was much indebted to Mr. Brodie for such an interesting paper. The lesser prevalence of gales

during February was simply due to its being three days shorter in length; for if 10 per cent were added to the number of February gales to make it comparable with January and March, it appeared that the February total was 5 per cent above the March total. He did not think Mr. Brodie was justified by the number of observations in drawing any conclusions as to the prevalence of gales during any particular five-day period, although 30 years might be ample for the grouping in months. He had little doubt that Mr. Brodie was correct in his explanation of the comparative absence of Northerly gales on the Channel coast, and he thought the same explanation might be given of the greater prevalence of Easterly gales on the east than on the west coasts. From his experience with kite-flying he had found that inland it was often blowing very hard at 2000 ft. elevation, when it was nearly calm at the surface, but that this rule did not hold when kites were flown from a vessel over the sea. Inland the isobars gave a perfectly reliable estimate of the wind force at an elevation of 1000 to 2000 ft., but they only gave a rough approximation to the wind at the surface; it seemed likely, therefore, that winds blowing from the land would be much lighter on the coast than they would be 20 miles or so out at sea.

Mr. F. C. Bayard inquired if Mr. Brodie thought that a 30 years' average gave a fair approximation to the truth. Dr. Mill, in dealing with rainfall, thought that averages for such a period gave tolerably good results, and it would be useful to know if such was the case in dealing with the number of gales on our coasts. He would like Mr. Brodie to explain why he thought the smoothed curve better than the actual figures.

Mr. R. H. Curtis remarked, with reference to what had been said as to the effect of land in reducing the strength of the wind, that he had recently had occasion to find out how frequently the force of a gale had been reported from North Shields by the Meteorological Office reporter during the last 3 years, and he could only find one occasion on which the force reported had reached 8 on Beaufort's scale. It was, however, certain, from the shipping disasters reported, that much stronger winds had frequently been experienced during that period not far out from the mouth of the Tyne. At Great Yarmouth, also, he had found that Westerly winds were decidedly stronger at the St. Nicholas Gat light-vessel, not much more than a mile off shore, than they were at the town itself; whilst, when the wind was Easterly, and therefore unobstructed, the agreement between the forces reported at the light-ship and on shore was much closer. As Mr. Brodie had not confined himself to shore stations for his data as to gales, this would not affect the reliability of his tables, but it might be of use to remember it when dealing with individual stations.

The President (Capt. D. Wilson-Barker) did not quite like the descriptive term "vortical gales." He thought it might imply that other gales were of a different character to the ordinary gales. The term, perhaps, "complete gales" would meet the case better, but he only threw that out as a suggestion.

Mr. F. J. Brodie, in reply, said that the favourable reception given to his paper compensated him in a large measure for the time and labour involved in its preparation. He was scarcely able to agree with the remarks made by Mr. Dines as to the increased storminess of March as compared with February being accounted for by the greater length of that month, inasmuch as the same feature was shown by the five-day means. He appreciated the force of Mr. Dines' criticism as to the imperfection of averages based upon observations made over so limited a period as 30 years. The objection applies in a measure to all the meteorological elements, but with the valuable information now in our possession it seems anything but heroic to sit still and to leave to posterity the task of unearthing facts, many of which are likely to differ very slightly, if at all, from those we are able to glean from the material already to hand. The remark

made in the paper as to the relative infrequency of gales blowing from off-shore directions applies, of course, in a degree to all the coasts. It must, however, be remembered that the data used in the discussion was not drawn from land observations only, but comprised records made at a large number of lighthouses and light-vessels, some at a fairly considerable distance from the shore. With regard to Mr. Bayard's inquiry as to the employment in one of the diagrams of smoothed curves, he (Mr. Brodie) felt strongly convinced of their value, many of the small and accidental irregularities being in this way partially, if not wholly, eliminated. It seemed natural that some exception should be taken to the use of the term "vortical," and the President's remarks on this point were not easily answered. The expression was, he admitted, not quite satisfactory, but after much consideration he had been unable to find a more appropriate one. The word "cyclonic" would not apply, inasmuch as all gales partook of that character. By the term "vortical" he intended to convey to the mind's eye the state of things prevailing when the centre, or vortex, of a storm came immediately over our islands, and when the circulation of wind in any one of the four divisions employed was more or less complete.

Formation of Cumulus Cloud.—Mr. W. H. Dines, in a letter to *Symons's Meteorological Magazine*, gives the following interesting observation on the formation of cumulus cloud :—

"I suppose no one doubts that a cumulus cloud is formed by an upward current of air, but when experimenting with a kite on April 29, 1903, I had a plain proof of the fact. A kite was left flying at the end of 2700 feet of wire, and flew at an angle of about 40°. A large and well-defined cumulus cloud then passed over, and the angular elevation of the kite increased rapidly until it reached the high value of 74°; an angle exceeding 70° being maintained for quite ten minutes while the cloud was overhead. The wind was blowing from South-south-west at a rate of, perhaps, 18 miles per hour, judged by the pull upon the wire, and was very uniform up to a height of 2500 feet. In such a wind the ordinary angle of the kite with 2700 feet of wire would be rather over 45°, so that we must suppose that the wind at a height of 2500 feet was inclined upwards at an angle of nearly 30°. This would give an upward component to the air of from 12 to 15 feet per second. A few heavy drops of rain fell from the cloud, and a fairly heavy shower seemed to be falling from it when it had passed a few miles away to the north. Its lower surface was above 2550 feet high ; how much above I cannot say, as it was not reached by the kite. The temperature at the ground level was 57°, at 2550 feet it was 43°."

Shrinkage of the Thames and Lea.—In December 1902 the Water Committee of the London County Council instructed their Chief Engineer "to report with reference to the diminution of the volume of water in the Thames and Lea, and dealing as far as possible with the question of the drying up of springs in connection with those two rivers." The Report was presented in February of the present year.

Mr. Fitzmaurice gives the following as a short summary of the conclusions arrived at. As regards rainfall, for the past 20 years there has been a decline over the Thames watershed of an annual average of nearly 2½ ins. below the mean rainfall of 28·50 ins., as computed by the late Mr. Symons for the 40 years 1850-1889 ; and this diminution has become more accentuated during the last 5 years. This decline is reflected in the diminished flow of the river as gauged at Teddington Weir, the natural flow having fallen to an average of

1110½ million gallons daily at the intake for the 20 years, compared with 1350 million gallons over the 1850-1889 period, showing a loss to the river of 239½ million gallons per day. As the diminished rainfall of 2½ ins. equals 105 million gallons per day (after making an allowance for evaporation, etc., of roughly 70 per cent), and the above diminished flow of 239½ million gallons shows a difference from this of 134½ million gallons daily, it would appear as though the condition of the river was becoming more acute, inasmuch as more rainfall would be required year by year to produce the long-period average rate of flow; in fact, what this means is that the percentage of total rainfall which reaches the river is diminishing as well as the total rainfall itself. Of course, against these facts we have the possibility of a long series of wet years, which may bring back the state of affairs which existed on the average during the long period mentioned.

What has been said above applies equally, although perhaps with more force, to the Lea valley.

With reference to auxiliary rivers, wells, and streams, attention is drawn to the almost unvarying records of diminished flow as apparently due in many cases, in addition to diminution of rainfall, to increased pumping, the most telling instance being the Chadwell spring, which dried up in the autumn of 1898 after giving an unfailing supply of water for over 300 years.

The chalk formation, which is the most important source of water supply in the south of England, is not the inexhaustible reservoir formerly supposed, but is essentially dependent on the annual rainfall, and this annual rainfall is not, at present, sufficient to maintain the requisite standard of saturation. The fact, as shown by the Royal Commission of 1893, that the water-level of the chalk below London is falling from 12 to 18 ins. per annum points to such a conclusion, although, of course, there are other relative causes tending to this result, such as increased pumping, better arterial drainage, large populated and covered areas, and an increased consumption and diversion of water. As regards London, the actual diversion represents about 200 million gallons daily in dry weather, increasing to over 400 million gallons in times of storm, which is removed from natural infiltration into the soil to an artificial outlet to the sea, by way of Barking and Crossness and the various storm overflows.

These naturally contributing causes of depletion are likely to be accentuated year by year, but as regards increased pumping and abstraction from districts little able to bear any further drain upon their own resources, a remedy ought to be found; but the law of underground water is so obscure that I am unable to make any suggestion in the matter.

From the above it will be seen that the causes of the water shrinkage are:—(1) Diminution of annual rainfall; (2) Diminution of the percentage of the total rainfall which reaches the river; (3) Increase in pumping to supply increase in population, etc.

The Report is divided into six sections, viz. (1) Introduction; (2) Geological; (3) Rainfall; (4) Flows of the Thames and Lea; (5) Springs, Wells, and Streams as Auxiliary Supplies; (6) Summary of Rainfall and Flow.

Appendix D contains an interesting diagram and table of 20 years' (1883-1902) daily average, monthly flow, etc., of the Thames at Teddington Weir, as well as the rainfall, temperature, sunshine, and relative humidity.

NOTE ON THE DURATION OF RAINFALL.

By JOSEPH BAXENDELL, F.R.Met.Soc.

[Read April 15, 1903.]

THE Rate of Rainfall during the past year (1902) was so unique that I venture to think that a few remarks on the subject generally may not be out of place.

At Southport, the Total Rainfall for the year amounted only to 25·42 in., which was no less than 8·00 in. below the local average for the preceding 30 years, and was a smaller total than had been registered in any year, with the single exception of 1887, during that period. Yet the days with rain numbered no fewer than 199, or 13 more than the average number. A somewhat similar state of things appears to have prevailed over the greater part of England.

A Halliwell "Float-Pattern" Self-Recording Rain Gauge, of the daily form, was in use at the Fernley Observatory, Southport, throughout the year. As the Total Rainfall deduced from the charts of this instrument agrees within less than a tenth of an inch with the mean of the year's totals from the 8-in. and 5-in. deep-rimmed gauges planted beside it, the Duration of Rainfall measured from its traces (which element the gauge is expressly designed to record with accuracy) may be thoroughly relied upon. The Total Duration of Rainfall for 1902, as determined by its means, was 640·1 hours. Hence, dividing the Total Rainfall by this result, we obtain as the mean Rate of Rainfall for the year the remarkably low value of 0·0397 in. per hour.

For many years Mr. Baldwin Latham has had in use at Croydon an expensive self-recording rain gauge of his own design, which the late Mr. Symons once remarked was probably the most perfect recording rain gauge in existence.[1] By its use (as Mr. Latham is kind enough to permit me to state) a Total Duration of Rainfall for 1902 of 529·35 hours was arrived at, and as the Total Rainfall there was 20·665 ins., the mean hourly Rate of Rainfall at Croydon for 1902 comes out at 0·0390 in., or, as it happens, less than a thousandth of an inch different to the Southport result. As I have already said, this rate is abnormally low, or, in other words, the length of time during which rain fell last year (in proportion to the amount) was very considerable. Mr. Latham informs me that the rate in question is little more than half the mean rate at Croydon for the four years 1879 to 1882 inclusive, the value for that period being 0·0650 in. per hour. And he adds that the average rate in even "the four years 1898 to 1901, was 0·0574 in., so that last year the rain seems to have been spread over a very long period in falling as compared with ordinary times."

Mr. Latham has for several months had in use one of Halliwell's "Float-Pattern" Self-Recording Rain Gauges, and he is of opinion that it furnishes records quite equal in accuracy to those obtained with his own special instrument.

That reliable records of Rain Duration from various parts of the country would be of no little interest to meteorologists and of decided

[1] *British Rainfall*, 1878, p. 48; and 1879, p. 39.

value to engineers will readily be admitted. Not only the duration and details of heavy falls, but the exact duration of all rainfall, including the finest drizzle, should evidently be carefully determined in at least a number of typical localities.

The various self-recording rain gauges hitherto in use, however, have unfortunately afforded little assistance in this direction, for most of them either (*a*) have their rims placed at a height of, at any rate, some feet above the ground,[1] which, as instanced below, may vitiate the record of Duration to a surprising extent; or (*b*) give "step-by-step" records,[2] quite useless for this purpose; or (*c*) are designed to record on a far too contracted scale[3] to render it practicable to deduce from their traces the duration of light rains with anything approximating to accuracy; while all are usually, in practice, more or less affected by friction, and few contain any satisfactory provision for melting snow as it falls.

The isolated annual Durations of Rainfall that are published frequently differ at least 10 per cent from the truth. For instance, the Total Duration of Rainfall at Southport for 1902, from the new Halliwell gauge, was, as already stated, 640·1 hours, but the corresponding value obtained with the old "improved"[4] Casella gauge, the rim of which is 4 ft. 6 in. above the ground, was only 573·6 hours. While at Bidston Observatory (less than 20 miles distant, and with, this year, a very similar total rainfall) the Duration derived from the Osler gauge actually amounted to 786 hours, the large excess in that case being probably the result of friction.

There is another and different feature of the more accurately ascertained Duration of Rainfall that promises to prove decidedly instructive. As is well known, even 20 years' records from the Meteorological Council's First-Order Observatories have failed to yield any very satisfactory mean curves of Diurnal Variation of Rainfall-Amount, the only really definite feature at all generally shown being the development of the continental afternoon maximum at each of the inland and eastern Observatories during the summer months, due doubtless to the thunder-showers and other rains resulting from the convectional processes in operation over land by day at that season. The very interesting early morning maximum of our western coasts is, unfortunately, far from conspicuous in most of these Amount curves, but it is noticeable in at least the case of Valencia (Ireland), where, indeed, it forms practically the only maximum in the 24 hours.

The "Number of Hours in which Rain fell" [*i.e.*, the number during at least some portion of each of which rain was falling] is given in the *Hourly Means*, published annually by the Meteorological Office, and is dealt with in Dr. R. H. Scott's valuable discussions[5] of the older observations (extending over 20 years), under the term "Frequency." Though this information is somewhat rude, and of course decidedly inferior to the exact Duration of Rainfall, it is yet very much better than nothing, and the figures for Valencia rarely, if ever, for a single year fail

[1] Osler's, Richard's, and various others.

[2] Negretti and Zambra's, and some others.

[3] *e.g.*, Beckley's. See *Report of the Meteorological Council*, 1901, pp. 103-104.

[4] The design of Casella's gauge was apparently extensively altered a number of years ago.

[5] *Quarterly Weather Report* for 1877, Appendix II.; and *Diurnal Range of Rain at the seven Observatories in connection with the Meteorological Office*, 1871-90 [Official No. 143].

to show a most conspicuous morning maximum, while distinct traces of one are also seen in the mean curves for most of those stations which are not very far removed from our western coasts. These "Frequency" values, however, show but little of the summer afternoon maximum, which is the main feature of those of Amount [or "Quantity"]. The striking Valencia morning maximum of Frequency is not confined to any particular months or season, but is spread over the entire year.

For the past year, the Amount, and exact Duration, of Rainfall, for every hour, have been carefully measured from the Halliwell traces at Southport, and while, for the complete year, the Amount hourly values only show a feeble afternoon maximum, the Duration ones give quite a striking curve of diurnal variation, the early morning maximum being most pronounced, and such as it is quite impossible to ascribe to chance; the afternoon one is also present, but is much less protracted, and of far less amplitude, than the former; minima occur about mid-day and in the evening. Should future years' results support the figures for 1902, as I have the best reasons for anticipating will be the case, it would be evident that at Southport, as at Valencia, the morning, or marine, diurnal maximum is mainly one of Duration of Rainfall, and only to a comparatively slight extent one of Amount (*i.e.* Quantity). Hence the Rate of the Rainfall is low (relatively to other parts of the 24 hours) in the best-developed morning maxima.

The hourly totals of Duration at Southport for 1902 are as follows:—

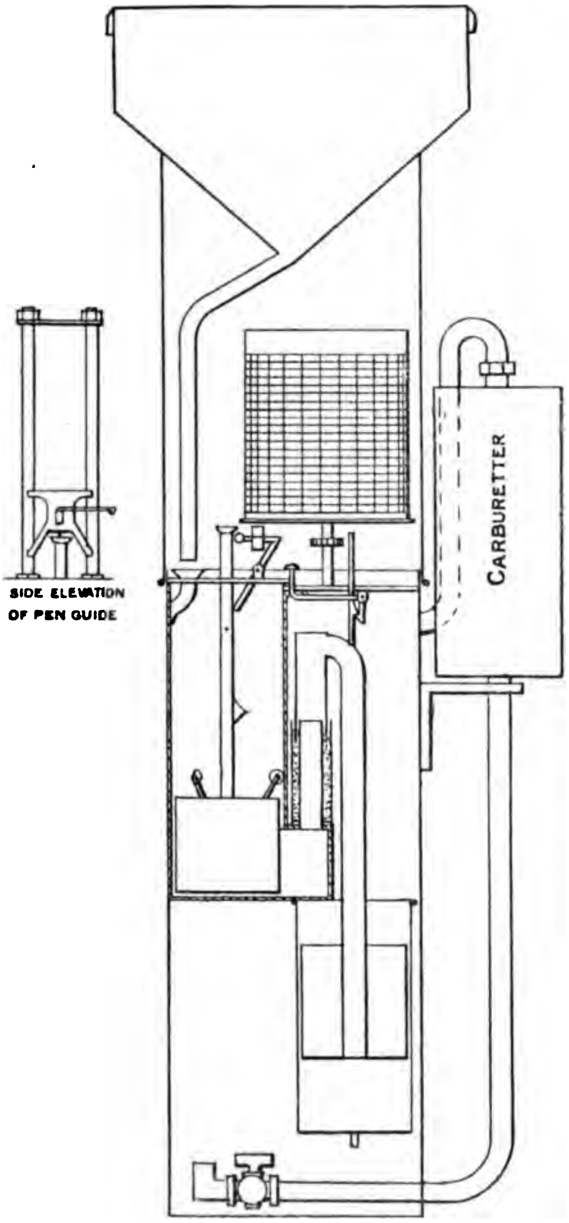
Hour.	Duration of Rainfall.	Hour.	Duration of Rainfall.
1 a.m.	25·1 hours.	1 p.m.	20·0 hours.
2 ,,	23·8 ,,	2 ,,	24·7 ,,
3 ,,	29·6 ,,	3 ,,	29·3 ,,
4 ,,	33·2 ,,	4 ,,	28·5 ,,
5 ,,	36·1 ,,	5 ,,	28·7 ,,
6 ,,	32·8 ,,	6 ,,	26·1 ,,
7 ,,	34·4 ,,	7 ,,	19·4 ,,
8 ,,	28·9 ,,	8 ,,	22·4 ,,
9 ,,	27·8 ,,	9 ,,	21·3 ,,
10 ,,	24·1 ,,	10 ,,	23·5 ,,
11 ,,	22·5 ,,	11 ,,	25·9 ,,
Noon	24·6 ,,	Midnight	27·4 ,,

As I believe that no notice of Halliwell's "Float-pattern" Self-Recording Rain Gauge has yet appeared in any journal or magazine, it may perhaps be worth while to conclude this paper with a brief description of the instrument.

In this gauge the rain from a deep-rimmed copper receiver[1] passes through a wide pipe to a cylinder, in which is a float bearing a vertical rod that raises or lowers a sliding anti-friction pen arrangement. As the water accumulates in the cylinder the float and pen rise, the latter recording continuously, in ink, on a non-stretching waterproof paper chart, the details of the rainfall. Shortly before the pen arrives at the top of the chart, a curved strip of metal attached to the float-rod begins to bear against the knob of a sensitively-poised weighted arm, and the latter being ultimately (at the right moment) turned over past its centre of gravity, falls suddenly, its elbow striking the knob of a catch-lever, which

[1] The diameter is 11 inches in the case of the Daily, and 8 inches in that of the Weekly pattern of the instrument.

releases a suspended very wide-bore siphon. The short leg of this siphon is always immersed in an annular vessel containing mercury that sur-



Halliwell's Float-pattern Self-Recording Rain Gauge.

rounds a water stand-pipe which leads from the lower part of the float-cylinder into the siphon. Immediately it is released the siphon drops until its bend, from being far above the water line in the cylinder,

becomes well beneath it, and therefore a full-bore discharge is instantly occasioned, the pen descending neatly to zero on the chart in five seconds. The construction of the siphon is completed by two long legs attached to a float that moves in a vessel which has only a (relatively) small outlet. The escaping water accordingly floats the siphon up again until it re-engages with the catch-lever. At the same time a pin on the descending rod lowering the pen arrangement automatically returns the weighted arm to the sensitive position which it occupied at the commencement.

With these arrangements, no "trickling" can possibly occur; and a faithful and distinct record is furnished by the gauge of either the heaviest tropical downpour or a wet fog or misty drizzle. The instrument is entirely free from frictional effects; the scale is uniform throughout; and the rain and time divisions on the charts are rectangular. The rain scale employed is about 5 in. of paper to 0·50 in. of rain in the daily pattern of the gauge, or to 1·00 in. of rain in the weekly pattern; the time scale is 15 in. of paper to a day (or a week), therefore agreeing, in the case of the daily charts, with the time scales adopted for Dines' Pressure Tube Recording Anemometer, and my Recording Anemoscope. The metal "well," containing the float-cylinder and the siphon, etc., is arranged to be almost entirely sunk into the earth. The rim of the gauge then stands 18 in. above the ground; and the amounts recorded by it will be found to be identical with the totals from the best eye-read rain gauges.

Attached to the instrument is a Notkin Carburetter, by means of which a perfectly safe, clean, and uniformly reliable flame, of any size, can be maintained inside the gauge, without any attention for a week or even a month at a time. Snow can therefore be melted as it falls, and all damage to the instrument from frost be prevented.

Although accurate results can be obtained with Halliwell's Balance-pattern Self-recording Rain Gauge, which I described to the Society on a previous occasion,[1] I consider the present [Float-pattern] instrument decidedly preferable to it.

DISCUSSION

THE PRESIDENT (Capt. D. WILSON-BARKER) remarked that the paper gave an account of a rain-gauge which clearly showed the difficulty of comparing one instrument with another, and results from different places with different instruments. Whether the instrument was perfect or not remained to be seen, but Mr. Baxendell was a good and careful observer and would doubtless be on the watch for anything unsatisfactory which might arise.

Mr. R. H. CURTIS said the curve of diurnal rain frequency yielded by Mr. Baxendell's figures for Southport for 1902 was in its main features very similar to the curves for Valencia, Falmouth, Aberdeen, and Kew, obtained from the observations for the 25 years 1871-95, published in the *Hourly Means* of the Meteorological Office for the latter year. At each of the five stations named there was a marked frequency of rain during the morning hours of the day, but at Valencia this frequency was much more pronounced than at either of the other stations. The hour at which rain most frequently falls at Valencia is 5 a.m. and the hour at which it is least frequent is 11 a.m., and there is a steady increase in the frequency from 11 a.m., through the

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxvi. p. 281.

afternoon and night, up to the maximum at 5 a.m. Between 5 a.m. and 9 a.m. there is a slight but steady decrease in the frequency, but from 9 a.m. to 11 a.m. the diminution becomes abrupt, and rain falls but little more than half as often at 11 a.m. as at 5 a.m. At Falmouth, Aberdeen, and Kew, 11 a.m. is again the hour of least frequent rainfall, but the morning maximum of frequency is less marked than at Valencia, and the increase during the afternoon hours is also less regular, and at Kew a slight secondary maximum is shown at about 3 p.m. He had also referred to an old paper on this subject by Mr. Glaisher, published in the Society's *Proceedings* for 1867, in which the frequency of rain at Greenwich during the years 1861-66 is dealt with. Mr. Glaisher's curve is unlike those for Southport and the Meteorological Office observations, except that the hour of least frequency is again 11 a.m.; but there is no marked maximum until 3 p.m., after which hour the frequency steadily falls away until 11 p.m. The gauge from which Mr. Glaisher got his figures was an Osler gauge 50 ft. above the ground level, and the amount of rain it registered was only 60 per cent of that collected by an ordinary gauge on the ground. Mr. Glaisher assumed that although the amount of rainfall was thus affected, the frequency was not, and therefore he used the figures without any qualification or correction. It seems more than doubtful whether this assumption was justifiable, and in it probably lies the explanation of the difference shown between Mr. Glaisher's curve and that for Kew and other places. As regards the amount of rainfall, the diurnal distribution does not coincide very closely with the frequency of its fall. At Valencia and at Falmouth it is greatest in the early morning, but at Kew the maximum fall is in the afternoon, and at Aberdeen there are maxima both in the morning and afternoon. With reference to the Halliwell rain-gauge he (Mr. Curtis) was able to confirm the praise which Mr. Latham had bestowed upon it. It was most ingenious in its arrangement, but at the same time extremely simple, and not liable to get out of order. He had had the charge of one at the Meteorological Office for many months, and although it was working then under very trying conditions for any instrument its action was very satisfactory. In his judgment it was by far the best registering rain-gauge to be had, and he hoped to see its use very much extended.

Mr. BALDWIN LATHAM said that he had had considerable experience in the working of the new form of Halliwell's gauge, and he considered it was a very perfect instrument. He had two of these at present at work at Croydon; he had also three of the tilting bucket pattern of the Halliwell gauge at work, which he did not consider so good as the new arrangement with float. With the tilting bucket arrangement any soot or dust blown into the gauge would act in the place of water, but with the float arrangement that was impossible. There was also another advantage in the Halliwell gauge, that the diagram could run for 25 hours, so that it was not necessary to change it exactly at the end of 24 hours if it happened to be raining at the time. The question of the rate at which rain falls was one of considerable importance to engineers, and it was one which had occupied his attention for a very considerable time. The instrument which he himself designed some years ago had been in operation ever since 1879, with the exception of a few days when it would be necessary for the clock to be cleaned. The principle of this gauge was a float gauge, but it differed from the Halliwell instrument, as in his own gauge the float was suspended by a silk cord, which he found, however, was liable to be affected by hygrometric conditions of the atmosphere. It is very important that self-recording gauges should be established all over the country. It was curious that last year the average rate of rainfall at Croydon had been smaller than for some years past, being only ·039 in. per hour. The actual rainfall was 20·665

ins., and the time of falling 529·35 hours. The average rate of fall at Croydon for the last 13 years had been ·05 in. per hour. Last year a Halliwell gauge of the tilting bucket pattern, at work on Melbury Moor, North Devon, at an elevation of 516 ft. above Ordnance datum, gave the total rainfall as 45·805 ins., which fell in 790·24 hours, or the average rate of fall was ·0578 in. per hour. At the pumping-station at Timsbury, near Romsey, in Hampshire, of the South Hants Waterworks Company, with a similar pattern gauge fixed at a level of 96·4 ft. above Ordnance datum, the rainfall was in the year 25·46 ins., which fell in 529·47 hours, or at the average rate of ·0481 in. per hour. At Twyford, another pumping-station of the South Hants Waterworks Company, not far from Winchester, a gauge fixed at an elevation of 139 ft. above Ordnance datum gave the rainfall last year as 27·69 ins., which fell in 468·82 hours, or at the rate of ·0591 in. per hour. The law which governs the rate at which rainfall increases has not yet been determined, but it appears to be probably in proportion to the amount of rainfall when divided by the number of rainy days in a particular place, a rainy day being counted as ·01 in. or more. In the case of Mr. Baxendell's record at Southport, however, he takes as a rainy day ·005 in. or more, so that the records at Southport are not comparable with other records, and it is desirable that some uniform plan should be followed with regard to indicating the number of rainy days which do occur in a district, but he believes in the late Mr. Symons' records a rainy day counts as ·01 in. or more of rain falling. Although the figures mentioned deal with the average, it will be noted that rain recorded in these recording gauges the maximum and minimum are recorded, and it is essential to know what are the maximum rates. At Croydon, in one day in November 1895, the rainfall was recorded as falling at the rate of 4·4 ins. per hour, but fortunately it was only of a short duration, and the time of falling did not exceed 5 minutes. As a rule, the recording rain-gauges show that heavy rains do not very often last long; and, of course, for all practical purposes a record of the actual time in which rain falls is the only one which can be really useful to the engineering profession. He trusted that gauges of this character would be multiplied and spread over the face of the country, so that at an early date we shall know something of the law which governs the rate at which rain falls so as to be able to apply the records of one place for use in another.

Mr. J. Hopkinson said that the peculiarity at Southport last year of the small total rainfall but great number of days of rain would probably be found to have been general over England. It was similar to that experienced in Hertfordshire, where the number of rainy days was excessive in comparison with the amount of rainfall, which was much below the average. Both "total" and "partial" droughts were absent, and the little rain which did fall was so frequent and continuous as to give a general impression that it was a wet year.

Dr. H. R. Mill wrote—"I regret that an engagement on the Continent made it impossible for me to be present at the meeting on April 15, as I should have liked to take part in the discussion on Mr. Baxendell's interesting paper. I cordially agree with his views as to the importance of obtaining accurate measurements of the duration and intensity of rain, and with what he said as to the difficulty, and in cases of light fall the impossibility, of obtaining good results with recording rain-gauges which only register the end-point of the collection of a certain small quantity of rain. In districts of excessive fall, such as Seathwaite, I have indeed seen fairly good results from the use of a Negretti and Zambra gauge recording hundredths of an inch; but the duration of very light showers could not be measured. Continuously-recording gauges, such as Casella's, yield results that cannot be improved upon, except by being more widely used all over the country, and the bar to their utility is their great cost. One of Mr. Halliwell's new recording gauges is at present in operation at

Camden Square, but so far it has not had a fair opportunity of being tested in heavy rain, and we cannot say from personal observation how far it overcomes the inherent difficulties presented by all syphon gauges with which I am acquainted. The trace is certainly very uniform and clear, well adapted for measuring duration.

"The number of days with rain is so unsatisfactory a test of the raininess, as distinct from the rainfall, of a place that I would gladly see it supplemented by the number of hours duration of rain for each month, a figure which could be instructively compared with the number of hours of sunshine."

Mr. J. BAXENDELL, in a note to the Secretary in reply, wrote :—"In reference to Mr. Latham's remarks as to the definition of a 'rainy day,' I should like to point out that the exact wording of Mr. Symons's 'RULE XII. SMALL QUANTITIES' is as follows: 'The unit of measurement being ·01, observers whose gauges are sufficiently delicate to show less than that are, if the amount is under ·005, to throw it away; if it is ·005 to ·010 inclusive, they are to enter it as ·01.' That Rule is strictly obeyed at Southport, and, I believe, at the majority of British First and Second Order Stations, including those in connection with the Meteorological Office. By the Royal Meteorological Society, ·006 has, for many years, been held to constitute a day with rain; while the limit adopted by the International Meteorological Conference is ·004 (or, rather, a tenth of a millimetre). These definitions are all virtually identical. But, unfortunately, at stations where rainfall alone is observed, as Mr. Symons used to say, the number of 'days with rain' is rather an indication of the carefulness of the observer than of the climate of the locality."

Local Factors influencing Climate.—The April number of the *Journal of Balneology and Climatology* contains a paper by Dr. C. W. Buckley, "On the Local Factors influencing Climate, with especial reference to Subsoil." He contends (1) that absolute humidity is one of the most important factors in climate, and depends chiefly on local conditions; (2) that geological formation in its widest sense has a great influence upon humidity (*a*) owing to nature of surface, and (*b*) owing to nature of subsoil; (3) that the soils most favourable to a low degree of absolute humidity are the impermeable rocks, namely, carboniferous limestone, granite, etc.; the next most favourable are the porous soils, so far as they are free from clay, namely the new red sandstone and the chalk; (4) the carboniferous limestone is the driest formation; (5) the amount of rainfall depends on the relation of surrounding hills (high rainfall does not entail a high degree of humidity, and, if the soil is a favourable one, gives greater purity of air); (6) altitude increases rainfall, but tends to decrease humidity. Dr. Buckley says that some of these conclusions will be generally recognised; others may be open to modification on further investigation.

REPORT OF THE COUNCIL

FOR THE YEAR 1902.

THE Council have the pleasure of congratulating the Society on its steady progress. There is an increase in the number of Fellows, whilst the usefulness of the Society is being recognised more and more, if an augmented correspondence is any criterion.

Committees.—The Council have been materially assisted during the year by several Committees, which have been constituted as follows:—

EDITING COMMITTEE.—Messrs. F. C. Bayard, R. Bentley, R. Inwards, and R. H. Scott.

GENERAL PURPOSES COMMITTEE. — The President, Secretaries, Treasurer, Messrs. R. Bentley, R. Inwards, and B. Latham.

KITE COMMITTEE.—The President, Secretaries, Mr. R. H. Curtis, Capt. M. W. C. Hepworth, and Capt. D. Wilson-Barker.

WIND-FORCE COMMITTEE. — The President, Secretaries, Messrs. R. H. Curtis, C. Harding, Capt. M. W. C. Hepworth, Mr. R. W. Munro, and Capt. D. Wilson-Barker.

Lecture.—A popular lecture on "Clouds," illustrated by numerous lantern slides, was delivered on April 16 by Capt. D. Wilson-Barker, at the request of the Council, in the lecture theatre of the Institution of Civil Engineers, and was much appreciated by a large audience.

The National Antarctic Expedition.—The sum of ten guineas has been contributed from the funds of the Society as a donation towards the expenses of the Expedition, in view of the valuable results likely to accrue to the science of Meteorology.

Registrar-General's Returns.—On the invitation of the Meteorological Council, Dr. R. H. Scott was appointed to represent the Society at a conference on May 8, respecting the supply of Meteorological information to be incorporated in the periodical Returns issued by the Registrar-General for England and Wales. The subscription for the Reports on the "Meteorology of England," hitherto supplied from the Registrar-General's Office for inclusion in the *Meteorological Record*, has been discontinued. The Council take this opportunity of mentioning that Mr. Glaisher, who has prepared these Reports for more than 50 years, has been obliged on account of his very advanced age to discontinue the preparation of the Returns. They understand that the work is at present being continued by the Meteorological Council.

Howard Medal.—The Howard Silver Medal annually awarded by the Society to the Cadets of the Nautical Training College, H.M.S. *Worcester*, was this year gained by Cadet R. T. Snape, for his essay on "The Meteorology of the Pacific."

Kite Committee.—In addition to the sum of £25 granted by the Council out of the Research Fund, and the sum of £75 by the British Association, a grant of £75 was made out of the Government Grant Fund administered by the Royal Society towards the expenses of this investigation. An additional sum of £25 was contributed by an anonymous donor, making the total receipts £200. The expenditure was

£281 : 13s. The Council directed that the balance of the expenditure over the receipts should be paid out of the Research Fund. Mr. Dines has carried out an important series of observations during the past summer on the west coast of Scotland, and the results will form the subject of his Presidential Address at the Annual Meeting. The Council desire to acknowledge their indebtedness to Mr. Dines and his two sons for the time and attention they devoted to the work. The Council have pleasure in announcing that the British Association have made a further grant of £75 towards next year's observations.

Research Fund.—This fund having been practically exhausted, the Council invited contributions towards its restoration, and they are happy to state that the sum of £61 has already been received; but additional contributions to this fund will be welcome.

Meetings.—With the exception of those in February, May, and June, which took place in the Society's rooms, the meetings of the Society were held as usual, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster.

Quarterly Journal.—The volume for 1902 consists of 312 pages, and contains the papers read at the Meetings of the Society, with the discussions thereon, and numerous notices of Meteorological interest. The following amongst other papers have appeared during the year:—The Presidential Address by Mr. W. H. Dines on "The Element of Chance applied to various Meteorological Problems"; "Meteorological Phenomena in relation to Changes in the Vertical," by Prof. J. Milne, F.R.S.; "La Lune mange les Nuages," by Dr. W. N. Shaw, F.R.S.; "The Prevalence of Gales on the Coasts of the British Isles during the 30 years 1871-1900," by Mr. F. J. Brodie; "The Report on the Wind-Force Experiments on H.M.S. *Worcester* and at Stoneness Point," by Mr. W. H. Dines and Capt. D. Wilson-Barker; "The Cornish Dust Fall of January 1902," by Dr. H. R. Mill; and "English Climatology, 1891-1900," by Mr. F. C. Bayard.

Meteorological Record.—Commencing with the year 1902, several changes have been made in this publication, which it is hoped will be considered improvements. These include maps showing the observed values and their relation to the twenty years' average (1881-1900) for temperature, rainfall, and sunshine during each month of each quarter. Diagrams showing the prevailing winds are also inserted.

Hints to Observers.—A new edition of this popular guide to meteorological work having been called for, the Council directed the insertion in it of "A Glossary of Meteorological Terms."

Stations.—Observations have been accepted from the following new stations: Dorchester, Dorset; Warminster, Wilts; and Gozo, near Malta.

Inspection of Stations.—All the stations in the north and north-east of England, and such others as could be conveniently visited, were inspected, and found to be on the whole in a satisfactory condition. Mr. Marriott's Report will be found in Appendix.

Phenological Report.—This valuable report was, as usual, prepared by Mr. E. Mawley, and read at the February meeting. The Council return

their best thanks to Mr. Mawley for his persevering labours in its preparation, and for the interesting information so usefully summarised.

Library.—The duplication of the Card Catalogue, in order to form a catalogue of subjects, has been proceeded with, and the work of checking the cards with the books and pamphlets is now in progress. While this is being done, the cards and the books are also marked with the number of the case and shelf on which the book is placed. Up to the present time the number of separate works dealt with in this way has been—

Bound volumes	4790
Pamphlets	7142
Maps and Charts	207

In the process of checking the Card Catalogue with the books and pamphlets, the necessity for further shelf accommodation became apparent. As it was difficult to find space for more book-shelves without altering the aspect and arrangement of the various rooms, the Council resolved to take a room in the basement of the same building at a rental of £12 per annum, and to place therein the Daily Weather Charts of the various countries which are not often required for reference. The Council directed three specially-designed cases of shelves on castors to be made for the reception of the Society's collection of photographs.

Meteorological Bibliography.—It will be remembered that, in the year 1900, the Society purchased from the executors of the late Mr. G. J. Symons the Meteorological Bibliography prepared by him, which contained between 60,000 and 70,000 titles. This work was carried on to nearly the end of 1899, and the Council considered it desirable that it should be continued. It was, however, deemed expedient to leave the Symons Bibliography intact, and to commence the Society's Bibliography with the year 1900. This consists of the titles of all books, pamphlets, papers, and articles bearing on Meteorology of which any notice can be found. The work takes a considerable amount of time to compile, as all books, periodicals, papers, and catalogues which are received by the Society have to be carefully examined for the purpose. It is not supposed that the Bibliography is by any means complete, as many works possibly do not come within the reach of the compiler, and therefore the Council would invite Fellows and others to send to the Society a copy of all meteorological books and papers of which they may be the authors, to ensure that an entry of the same is made in the Bibliography. This work was commenced in the spring of 1901, and up to the present time 7733 cards have been prepared, of which 4642 were made during the past year.

The Council have also undertaken to furnish for the International Catalogue of Scientific Literature the titles of works bearing on Meteorology which are published in the British Isles; and during the past year 505 Catalogue Cards have been prepared and forwarded to the Central Bureau.

Offices.—The Council have altered the hours on Saturday, so as to close the office at 1 p.m. instead of 2 p.m. as hitherto.

For Continuation of Report of the Council, see page 198.

APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1901		£145 18 11
Subscriptions for 1902	£841 0 0	
Do. for former years	66 0 0	
Do. paid in advance	40 0 0	
Life Compositions	105 0 0	
Entrance Fees	58 0 6	
		1110 0 6
Meteorological Office—Copies of Returns	£105 19 1	
Do. Grant towards Inspection Expenses	25 0 0	
		130 19 1
Dividend on Stock (including £47 : 9 : 3 from the New Premises Fund)		142 13 9
Sale of Publications, &c.		51 5 8
		£1580 17 11

I.

FOR THE YEAR ENDING DECEMBER 31, 1902.

EXPENDITURE.

Journal, &c.—		
Quarterly Journal, Nos. 121 to 124	£157 8 3	
Illustrations	24 5 9	
Authors' Copies	13 8 0	
Meteorological Record, Nos. 82 to 85	75 2 6	
Reprints from the Registrar-General's Returns	3 4 7	
		£273 9 1
Printing, &c.—		
General Printing	£21 1 0	
Hints to Meteorological Observers, 5th edition	65 18 6	
List of Fellows	16 11 0	
Stationery	17 14 1	
Books and Bookbinding	16 10 0	
		137 14 7
Office Expenses—		
Salaries	£587 6 10	
Rent and Housekeeper	200 0 0	
Coals, Lighting, and Insurance	16 18 0	
Furniture and repairs	17 11 9	
Postage	74 19 4	
Petty Expenses	17 5 3	
Refreshments at Meetings	14 8 8	
		928 9 10
Observations—		
Inspection	£50 6 6	
Observers	11 4 0	
Instruments	5 16 4	
Contribution to the National Antarctic Expedition	10 10 0	
		77 16 10
Stock—		
Purchase of £130 Western Australia Government 3 per cent	£120 15 9	
Do. £12 L. & N.W.R. 4 per cent Preference Stock	15 0 0	
		135 15 9
		£1553 6 1
Balance—		
At Bank	£13 19 1	
In hands of the Assistant-Secretary	13 12 9	
		27 11 10
		£1580 17 11

Examined, compared with vouchers, and found correct,

T. P. NEWMAN, *Auditor.*

January 15, 1903.

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

To Subscriptions paid in advance	£40 0 0	
,, Rent for quarter ending December 25, 1902	50 0 0	
		£90 0 0
,, Excess[1] of Assets over Liabilities		3619 16 11
		£3709 16 11

[1] This excess is exclusive of the value of the Library, the Stock of Publications, and the Symons Bibliography and Bequest.

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Amount paid to the Society's Fund towards the rent of rooms at 70 Victoria Street	£47 9 3

RESEARCH FUND,

Amount paid towards the Kite Observations, 1902	£131 13 0
Do. Wind Force Experiments	2 5 6
	£133 18 6
Purchase of £63 : 2 : 1 Consols	58 14 6
	£192 13 0

I.—Continued.

ON JANUARY 1, 1903.

ASSETS.

By Investment in Great Central Railway 4½ per cent Debenture Stock, £800 at 137	£1096 0 0	
,, Investment in New South Wales 4 per cent Inscribed Stock, £654 : 18s. at 109	713 16 10	
,, Investment in London & North-Western Railway Consolidated Stock, £400 at 168¾	675 0 0	
,, Investment in London & North-Western Railway 4 per cent Preference Stock (1902), £12 at 127¼	15 5 5	
,, Investment in Western Australia Government 3 per cent Inscribed Stock 1927, £130 at 91½	118 19 0	
,, Investment in 2½ per cent Annuities, £231 : 11 : 9 at 94	217 13 10	
		£2836 15 1
,, Subscriptions unpaid, estimated at	£50 0 0	
,, Entrance Fees unpaid	8 0 0	
,, Interest due on Stock	54 3 10	
,, Meteorological Office—Weekly Returns, 1902	28 4 0	
		140 7 10
,, Furniture, Fittings, &c.	£562 4 10	
,, Instruments	142 17 4	
		705 2 2
,, Cash at Bank of England	£13 19 1	
,, Cash in hands of the Assistant-Secretary	13 12 9	
		27 11 10
		£3709 16 11

Examined, and securities seen at the Bank of England,

January 15, 1903. T. P. NEWMAN, *Auditor.*

DECEMBER 31, 1902.

Interest received on Investment	£47 9 3

Note.—The Society holds on account of this Fund £1443 : 7 : 9 South Australian 3½ per cent Inscribed Stock.

Examined, and certificate seen at the Bank of England,

January 15, 1903. T. P. NEWMAN, *Auditor.*

DECEMBER 31, 1902.

Interest received on Investment	£3 2 3
Contributions—Anonymous Donor (for Kite Observations)	25 0 0
A Member of the Council	21 0 0
Mr. F. C. Bayard	10 0 0
Mr. W. H. Dines	10 0 0
Dr. C. Theodore Williams	20 0 0
	£89 2 3
Sale of £112 Consols	103 10 9
	£192 13 0

Note.—The Society holds on account of this Fund £65 : 6 : 10, 2¾ per cent Consols.

Examined,

January 15, 1903. T. P. NEWMAN, *Auditor.*

APPENDIX

SYMONS MEMORIAL

Balance from 1901	. . . .	£40	12	10
Interest received on Investment, 1902	. . . . . .	16	18	3
Income Tax returned	. . . .	1	10	0
		£59	1	1

KITE OBSERVATIONS

British Association (per Dr. W. N. Shaw)	. . . . .	£75	0	0
Government Grant Committee	. . . .	75	0	0
Royal Meteorological Society (Research Fund)	. . . . .	131	13	0
		£281	13	0

I.—Continued.

MEDAL FUND, 1902.

Gold Medal, 1902	£25 0 0
Purchase of £30 Cardiff Corporation Redeemable Stock at 95	28 10 0
	£53 10 0
Balance at Bank of England	5 11 1
	£59 1 1

Note.—The Society holds on account of this Fund £630 Cardiff Corporation Redeemable Stock, 3 per cent.

I have seen at the Bank of England certificates for the above-mentioned Stock, and there is a balance at the Bank of England in favour of the Fund of £5 : 11 : 1.

January 15, 1903. T. P. NEWMAN, *Auditor.*

FUND, 1902.

Hire of Tug	£141 0 0
Engine and Boiler	50 0 0
Meteorograph	20 5 0
Wire	18 15 10
2 Cody Kites	5 0 0
Carriage of Goods	7 14 4
Sundries, including Winding Gear and Kites	38 17 10
	£281 13 0

Examined,

January 15, 1903. T. P. NEWMAN, *Auditor.*

Fellows.—The changes in the number of Fellows are given in the following Table, which shows an increase of nineteen during the year:—

Fellows.	Annual.	Life.	Honorary.	Total.
1901, December 31	479	148	19	646
Since elected . . .	+ 62	+ 5	+ 2	+ 69
Deceased	− 5	− 3	− 2	− 10
Retired	− 17	...	...	− 17
Lapsed	− 18	...	...	− 18
Struck off	− 5	...	...	− 5
1902, December 31	496	150	19	665

Deaths.—The Council have to announce with much regret the deaths of two Honorary Members and eight Fellows, viz.:—

Sir Daniel Cooper, Bart., K.C.M.G.	elected Feb. 17, 1864.
Samuel Dixon	„ Feb. 18, 1885.
Edward Amos Peak	„ Feb. 20, 1895.
Edwin Josiah Poyser	„ Jan. 17, 1900.
Emilien Jean Renou (Hon. Mem.)	„ June 16, 1875.
Frank Taylor, J.P.	„ Dec. 20, 1899.
Richard Tyrer, B.A.	„ Apr. 19, 1871.
James Penman Hugh Walker, M.Inst.C.E.	„ Nov. 17, 1875.
Capt. William Watson	„ Feb. 20, 1878.
Dr. Heinrich Wild (Hon. Mem.)	„ June 17, 1874.

APPENDIX II.

INSPECTION OF STATIONS, 1902.

All the stations in the north and east of England have been visited, and were found to be generally in a very satisfactory condition.

The number of thermometers tested has been 154, in 32 of which there was found to be a change of zero.

It was satisfactory to hear that at one station where the maximum thermometer had got out of order during the winter, owing to the air bubble working into the bulb, that the observer had completely re-adjusted the thermometer by following the directions given in the *Hints to Observers.*

The wet-bulb is admittedly somewhat difficult to manage during frosty weather, but if the bulb is wetted about half an hour to an hour previous to the time of observation it will usually give a reliable reading. I have myself found that by wetting the bulb immediately after the 9 p.m.

observation I have often been able to get a satisfactory reading of the wet-bulb thermometer the next morning. I have therefore recommended those observers who have a difficulty in getting to their instruments early in the morning, to well wet the bulb the previous evening rather than lose the reading altogether.

At three stations I found that the observers were not properly measuring the cards of the Campbell-Stokes sunshine recorder. In one case the measurements were considerably and persistently in excess of the proper amounts, while in another case the amounts were even as much as one hour in defect! I have requested these observers to send up their sunshine cards to the Society's office for re-measurement.

At one station where there are two rain-gauges, one of which is measured monthly and the other daily, the observer called my attention to the fact that the former gave a larger amount than the latter. Upon inquiring closely into the matter I found that the observer had been accustomed to throw away the rain if it did not amount to ·01 in. This probably accounts for the deficiency. I urged the observer for the future not to throw any water away but to keep it in the gauge until the next measurement.

It seems strange that instrument-makers do not always supply thermometers suitable for the purpose for which they are bought and, presumably, sold. At one station I found a small 4 ft. earth (spirit) thermometer which was graduated from 25° to + 120°, and so the scale was very much contracted. For earth temperature observations in this country the thermometers should have a much smaller range, and consequently a more open scale.

WM. MARRIOTT.

October 15, 1902.

NOTES ON THE STATIONS.

APPLEBY, *July* 15.—The instruments were in good order. I recommended the observer always to read thermometers to tenths of a degree.

BELPER, *August* 15.—There was no change in the zeros of the thermometers. The screen required painting. I recommended that the conducting thread should go direct to the water receptacle without any bend, and that the cup should be kept filled with water. There is a great difficulty in getting a proper sky view owing to the place being very much shut in by trees. At my request Mr. Hunter agreed to observe the amount of cloud for some time at his own house, and then to compare the results with those taken by Miss Hunter at Field Head House.

BLACKPOOL, *July* 18.—The instruments had been moved to the site selected at the previous inspection. The sunshine recorder had been removed from the North Pier and was mounted on a wooden staging about 20 ft. above the ground, near the other instruments. The recorder was not in proper adjustment for time, being about 10 minutes slow. The thermometer screen required painting. A Negretti and Zambra self-recording rain-gauge (which was formerly in use at Seathwaite) was placed along with the other instruments, but it required some readjustment. A Dines self-recording pressure-tube anemometer had been erected on the pavilion of the North Pier. It would be an advantage if the "head" of the anemometer could be carried up higher, so as to be above the influence of the building.

BOLTON, *July* 30.—This station was in good order. On comparing the thermometers it was found that the 6 in. earth had gone up 0°·3. I was informed that the muslin on the wet-bulb is regularly changed every fortnight.

BOWNESS, *July* 16.—Since the death of Mr. R. Waters, the Secretary of the Hydro, Mr. Biggs has taken the oversight of the Jordan sunshine recorder. I arranged with him for the sunshine papers to be sent up to the Society monthly for re-measurement.

BRIGHTON, *October* 3.—On comparing the thermometers it was found that the dry and wet had both gone up 0°·1, the maximum 0°·2, and the spare maximum 0°·2. As the maximum had a tendency to give too high a reading, owing to the mercury running up the tube without any apparent reason, I recommended that the spare maximum be used in place of this thermometer. The grass minimum had about 2° of spirit up the tube. The sunshine recorder was not in proper adjustment, the ball being too high. I gave the observer instructions how to set it right.

BRUNDALL, *September* 2.—This station was in good order. On comparing the thermometers it was found that both the dry and wet had gone up 0°·1. Apparently sufficient attention had not been given to the wet-bulb in frost, so I made suggestions for obtaining more satisfactory results. Mr. Preston contemplated putting up a Jordan sunshine recorder. I examined a site for the same, which seems suitable if the recorder were mounted on a post about 15 ft. or 20 ft. high.

BUXTON, *August* 16.—The substance used with the wet-bulb thermometer was a piece of bandaging. I recommended that muslin and cotton be employed. As the maximum thermometer has 3 air specks in the column, I recommended that special attention should be paid to the setting of the instrument in order to prevent too high a reading being registered. The column of mercury forming the index was very long, and it seems probable that the air speck may work down into the bulb at low temperatures. I explained to the observer how the measurement of snow should be effected. The Jordan sunshine recorder was not in proper adjustment, being set for lat. 57° instead of 53°, and being also slow in time.

CHEADLE, *August* 14.—This station was in good order. On comparing the thermometers it was found that the dry and wet had both gone up 0°·2. The grass minimum thermometer had some spirit up the tube. This thermometer is sometimes difficult to read owing to moisture getting in between the tube and the outer jacket. The grass minimum thermometer in use some time ago read too high. It was sent to the maker for examination, but was broken in transit.

CORTON, *September* 2.—The sunshine recorder was working satisfactorily. The trees and shrubs have grown considerably, and if not already intercepting some of the sunshine they will very soon do so. I recommended that the recorder should be raised fully 10 ft. It might also with advantage be placed farther to the south.

DERBY, *August* 14.—This station was not in a satisfactory condition. The screen was very dirty, and greatly needed cleaning and painting. The wet-bulb was covered with a piece of old muslin, and was *immersed* in the water in the glass receptacle. The rain-gauge had recently been stolen, so a new one had been obtained. The rim of the gauge was only 6 in. above the ground. I recommended that it be raised to 1 ft. On comparing the thermometers it was found that the wet-bulb had gone up 0°·1.

ELY, *August* 27.—The screen required strengthening and painting. On comparing the thermometers it was found that the wet-bulb had gone up 0°·1. The grass minimum had 2° of spirit up the tube, which I shook down, but it then still read 0°·9 too low.

GELDESTON, *September* 1.—The sunshine recorder was in the same position as at the previous visit. The wedges fixing the instrument had slipped, so that the recorder was not quite right for time.

HARROGATE, *July* 7.—The instruments are well exposed in a large railed-off enclosure on Corporation land. I recommended that a cover be put over the water receptacle. The two sunshine recorders are placed on the roof of a hut, used as an office, and have a very good exposure. The ball of the Campbell-Stokes recorder was too high. The observer had considerably over-estimated the records of sunshine. I requested him to send up the cards to the Society for re-measurement.

HILLINGTON, *August* 26.—There was no change in the zeros of the thermometers. The grass minimum had some spirit up the tube. I shook most of this down, but could not dislodge all of it. I recommended that close attention be paid to the working of the wet-bulb thermometer. Mr. Ffolkes was away in Italy during the first half of this year on account of health, and during that time the observations were taken by the gardener, who, unfortunately, did not keep the wet-bulb in good working order.

HODSOCK, *August* 25.—This station was in good order. On comparing the thermometers it was found that the grass minimum had gone down 0°·5. A 4 ft. earth thermometer had been added since the previous inspection. A tree to the east-south-east of the sunshine recorder makes an angle of 9°, and probably intercepts a little of the morning sun in the spring and autumn.

LANCASTER, *July* 17.—The Greg Observatory is now under the superintendence of Mr. French. The meteorological observations are taken by a lad who is likely to become a good observer. The Beckley self-recording rain-gauge was not working properly. It required to be thoroughly overhauled and cleaned. The ball of the sunshine recorder had a tendency to slip down.

LINCOLN, *August* 21.—This station was in good order. Mr. Bromhead proposed having a double top put on the thermometer screen. On comparing the thermometers it was found that the dry had gone up 0°·2, and the wet 0°·1. The electrical thermometer on the great tower of the Cathedral appeared to be in a satisfactory condition.

LOWESTOFT, *September* 2.—There was no change in the zeros of the thermometers. The sunshine recorder was not in proper adjustment for time. The trees and shrubs have grown and are still growing—if they do not already they soon will cut off some of the sunshine. I therefore recommended that the sunshine recorder be raised so as to be clear of any possible obstruction. The direction of the wind is taken at the upper lighthouse, and the force of the wind at the lower lighthouse. I recommended Mr. Edwards to take the direction and the force of the wind himself, and to compare the results with those at the lighthouses.

MACCLESFIELD, *August* 18.—The thermometer screen required painting. The pipe of the rain-gauge funnel was loose and needed repairing. The minimum thermometer had 0°·7 of spirit up the tube. On comparing the thermometers it was found that the dry, wet, and maximum had all gone up 0°·1. Mr. Roscoe, owing to the nature of his employment, has to take the observations some time before 9 o'clock.

MELTHAM, *August* 19.—The earth thermometers, which are Negretti and Zambra's pattern, are placed in a good situation. They are, however, protected by a wooden cover which appeared to me to be unnecessary. Mr. Brook proposes placing another earth thermometer close by, uncovered, and seeing whether there is any difference between the two. On comparing the thermometers it was found that both the 1 ft. and 2 ft. had gone up 0°·1.

RAVENSCAR, *July* 9.—The instruments were in good order. I had some conversation with the Rev. A. L. Becker about the methods of observation and the making up of the returns which, if carried out, will be of great advantage. Ravenscar is a very bleak place, and the observer no doubt has great difficulties to contend with in rough weather.

RAVENSTHORPE, *September* 17.—The instruments were in good condition. I recommended that the water receptacle be placed in a better position. On comparing the thermometers it was found that the wet-bulb had gone up 0°·2. The former observer, Mr. Wilson, left at the beginning of August, his place being taken by Mr. Dickens, whom I instructed in the use of the instruments and in the method of observing.

ROTHBURY, *July* 12.—The instruments were in good order. I gave the observer some back-plates with hole and slot to put on the maximum and minimum thermometers. I requested the observer always to read the thermometers to tenths of a degree. The sunshine recorder required screwing up. I found that the sunshine cards had not been properly measured, so I requested that the cards should be sent up to the Society for re-measurement.

ROUNTON, *July* 10.—The observer has some difficulty with the wet-bulb thermometer in frost, but I explained to him how to act under such circumstances. The index of the Phillips' maximum thermometer is smaller than in most similar thermometers. The grass minimum thermometer was 0°·8 too low.

SCALBY, *July* 14.—There was no change in the zeros of the thermometers. I altered the position of the water receptacle and recommended that a cover be put over it. I urged the observer to pay special attention to the working of the wet-bulb, and also explained how to measure snow.

SCARBOROUGH, *July* 8.—The minimum thermometer had an air bubble in the column of spirit, which I removed. The bright bulb thermometer had 3°·2 of mercury detached from the column. The sunshine trace was not running parallel with the card. As there was no sunshine at the time of my visit, I was not able to readjust the recorder. The observer did not appear to properly estimate the force of the wind, nor the amount of cloud. I urged him to adhere to the scales authorised by the Royal Meteorological Society. During the present year observations have also been made at the Manor Road Nursery. This is a much better site than the present one at the Peasholme allotments, the ground being level and the exposure very good. I recommended that the present station be discontinued at the end of this year, and that the new one at the Manor Road Nursery be made the recognised station.

SEATHWAITE, *July* 15.—The instruments were in good condition. I recommended that the screen be painted. The self-recording rain-gauge, which I set up for the late Mr. Symons at my previous inspection, was removed last autumn to Blackpool.

SLOUGH, *September* 24.—The sunshine recorder was not in proper adjustment for time. The ball was loose and required clamping.

SOUTHPORT, *July* 19.—Everything at this station was in good order. The ground on which the instruments are exposed is surrounded by trees and shrubs. Although the trees are not yet too high seriously to affect the results, the shrubs

have become so thick that they have made the enclosure very confined. I recommended that the shrubs be thinned out to allow of more circulation of air. Several new instruments have been added since my previous visit, viz. Halliwell's self-recording rain-gauge and a 20 ft. earth thermometer, as well as a second Dines pressure-tube anemometer and a Halliwell anemoscope.

SOUTHWOLD, *September* 3.—This station is in good order. I recommended a rearrangement of the thermometers in the screen, and also that the legs of the screen should be strengthened. The Jordan sunshine recorder was out of adjustment, being set for lat. 49° instead of 52°, and was also 20 minutes fast. I recommended that the caps and upper part of the iron tubes for the earth thermometers should be painted white.

STRELLEY, *August* 15.—On comparing the thermometers it was found that the minimum had gone down 0°·1. The screen required painting. Mr. Edge has a daily and a monthly rain-gauge; the latter registers a larger amount than the former. I ascertained that Mr. Edge was accustomed to throw away the rain if it did not amount to ·01 in. This may no doubt account for most of the deficiency. I recommended him for the future not to throw away even the smallest amount, but to retain it until the next measurement. The sunshine recorder was in good adjustment. There is no doubt that the trees on the east-north-east to south-east cut off some of the early morning sunshine.

USHAW, *July* 11.—There was no change in the zeros of the thermometers. As there was to be a change of observer in the course cf a few weeks' time, I saw and gave instruction to the proposed new observer, and also to the deputy who would take the readings during the holidays.

WAKEFIELD, *August* 20.—The instruments were in good condition. By special permission of the Governor of the Prison, I had the opportunity of seeing the observer take the evening observations. I had not seen this observer before, as he is always resting in the daytime. I urged that special attention should be given to the wet-bulb thermometer during frost. On comparing the thermometers it was found that both the dry and wet bulbs had gone up 0°·1.

WRYDE, *August* 26.—On comparing the thermometers it was found that the dry and wet had both gone up 0°·2, and the maximum 0°·1. I recommended that the legs of the screen be strengthened by cross-pieces of wood. I explained the method to be adopted with the wet-bulb in frost, and recommended that the muslin be wetted about an hour before the time of observation, in order to allow a coating of ice to be formed round the bulb.

APPENDIX III.

OBITUARY NOTICES.

Sir DANIEL COOPER, first baronet, of Woollahra, was the second son of Mr. Thomas Cooper, of Double Bay, near Sydney, New South Wales, and was born at Bolton-le-Moors on July 1, 1821. He was educated at University College, London, and went to Australia in 1843. In 1848 he was elected a member of the Legislative Council of New South Wales. In 1856, after the grant of responsible Government to the Colony, he was returned to the first Legislative Assembly for Sydney Hamlets, and was chosen the first Speaker of the new body, a position which he held until 1860. After his resignation of that office he was

asked, but declined, to form an Administration in succession to the Forster Ministry, and in 1861 he returned to England.

During the Crimean war and the Lancashire cotton famine he took an active part in the promotion of the fund in Australia for the relief of the sufferers, and for this and other public services he was knighted in 1857, created a baronet in 1863, and received the K.C.M.G. in 1880, and the G.C.M.G. in 1886.

Sir Daniel Cooper after his return to England acted on several occasions as Agent-General for New South Wales. He was a member of the Royal Commission for the Colonial and Indian Exhibition in 1886, and he represented the Colony at other great exhibitions in Europe and America.

He died on June 5, 1902, in his 81st year.

He was elected a Fellow of this Society on February 17, 1864.

EDWIN JOSIAH POYSER was born at Beccles on September 1, 1861. He was educated privately, and finally went to Pembroke College, Cambridge. He was for many years Commodore of the Yare Sailing Club, and on his yacht, the *Ianthe*, dispensed the most lavish hospitality. He was a capital all round sportsman, and was quite an expert at big game shooting.

Mr. Poyser died at Dunburgh House, Geldeston, near Beccles, on June 12, 1902.

He was elected a Fellow of this Society on January 17, 1900.

EMILIEN JEAN RENOU, who was elected an Honorary Member of this Society June 16, 1875, was born at Vendôme, March 8, 1815, and was sent to the Lycée at that place. In 1835 he entered the Ecole Polytechnique, and studied under Elie de Beaumont. Later on he went to Germany, and *inter alia* attended the lectures of Gauss at Göttingen. From 1839-1842 he was employed on the Scientific Commission of Algeria, and published a *Description géologique* of that colony. In 1846 he was directed to collect all available information as to Morocco, and the result was an important work, *Description de l'Empire du Maroc.* He subsequently revisited Algeria at his own expense, to reverify his previous geographical determinations.

In 1850 Renou resolved to adopt meteorology as his almost exclusive pursuit, and he was one of the founding members of the Société Météorologique de France in 1853. He has published several papers in its *Annuaires* and was its Secretary for eleven (not consecutive) years. He was four times elected to the Presidency, an annual office.

In 1868 he was one of the members of a Committee, under the Presidency of Prof. Charles St. Claire Deville, for the reorganisation of the observatory of Montsouris. After the events of 1870-72 this observatory was placed under the Municipality of Paris. Mons. Marié Davy was appointed Director, and Renou had to leave.

In 1872 he was appointed Director of a laboratory for meteorological research, an office which he held till his death. This establishment was first placed at Choisy le Roi, but it was soon removed to Parc St. Maur, to a locality rented by Mons. Renou.

On the official organisation of the Bureau Central de Météorologie de France, Renou's station was selected as the central station for the

climate of Paris, and the instruments were moved to a plot of ground which was assigned to the Bureau, and where they still remain.

Renou has contributed to the *Annales* of the Bureau three important papers on the climate of Paris.

Emilien Renou was crowned with honours. Of the Legion of Honour he was Chevalier 1847, Officier 1884. He was also Officier de l'Académie (1873) and Officier de l'Instruction Publique (1891).

He died at the age of 87, at Parc St. Maur, April 6, 1902, and he has bequeathed his extensive collection of books to the Library of Vendôme, his native place.

FRANK TAYLOR was born at Bolton, August 16, 1843, and was the second son of Alderman James Taylor. He began his business life in his father's foundry, and he at once insisted upon going to work at the same early hour as the other workmen. Subsequently he went to assist his brother in the cotton-spinning mill (Charles Taylor and Brother), of which he afterwards became chief manager from the time of his brother's death to his own retirement from business a few years ago.

Mr. Taylor, who was an active member of the Unitarian Church, was one of the original promoters of the Bolton branch of the National Education League; and afterwards, when the School Board system was established, he became in 1875 a member of the Bolton School Board. He was for a considerable time an Income Tax Commissioner. In 1885 his name was placed on the Commission of the Peace for the borough, and he was made a County Magistrate in 1894.

He died at Birkdale on July 30, 1902.

He was elected a Fellow of this Society on December 20, 1899.

RICHARD TYRER, who died on May 4, 1902, aged 63, was a B.A. of London University. For some years he with his brother kept a school at Mansfield, and in 1878 he became headmaster of The Modern School at Cheltenham, a post which he held till his death.

He was beloved without exception by the boys who passed under his hands. Broad-minded in the true sense of the term, of even temper and kindly disposition, he guided those in his care through personal respect and affection, and he encouraged his pupils' interest in field games, in country rambles, and in swimming, for which exercise the lake in his grounds was adapted, and up till a few years ago he played cricket with the school. He occasionally took the elder boys chain-surveying, holding that, besides the benefit to be derived from instruction in the open air, a knowledge of the practical uses of geometry was thus acquired which conduced to the interest in its study.

Outside his school work public life had few attractions for him, and at no time did he take prominent share in the affairs of the community. Of all nature-study he was an ardent follower; devoted to his garden, he succeeded in producing more than one new species of flower. His chief relaxation was a long country walk, and indeed he regarded this form of exercise as a panacea for the few little illnesses that beset him before that which had fatal termination. These long rambles enabled him to indulge in the study of geology and of entomology, good collections in which (particularly in the Coleoptera) he had acquired. Possessed of excellent instruments, he entered into micro-

scopical research work with success. He had gathered a fine collection of coins, chiefly English.

He was a most careful meteorological observer for this Society both at Mansfield and at Cheltenham, and for many years he discharged the practically honorary duties of Borough Meteorologist for Cheltenham.

He was elected a Fellow of this Society on April 19, 1871.

JAMES PENMAN HUGH WALKER, who was the son of Capt. Robert Walker, R.N., was born at Windywalls, near Kelso, on April 7, 1834. After being educated at Kelso and Jedburgh, he served a pupilage of five years with Mr. John Murray, C.E. On the expiration of his pupilage he was employed under Mr. Murray from 1856 to 1858 as an assistant on the North Graving Dock and other works connected with the Sunderland Docks. In August of the latter year he was appointed an Assistant Engineer on the Great South of India Railway, which post he held until the autumn of 1862, when he entered the service of the East Indian Irrigation and Canal Company as an Executive Engineer on the weirs, canals, and other undertakings connected with its irrigation works at Orissa. When the Company's works were taken over by the Public Works Department of the Government of India in 1869, his services were retained; and he subsequently became Superintending Engineer of the Orissa and the Sone Irrigation Circles.

Mr. Walker resigned his appointment in the Public Works Department, on account of ill health, in 1879, and from that time lived in retirement in England. He died at Sutton, Surrey, on January 11, 1902.

Mr. Walker, who was a Member of the Institution of Civil Engineers, was elected a Fellow of this Society on November 17, 1875.

Capt. WILLIAM WATSON was born in the year 1833 at Bury, and entered the service of the Cunard Company as a junior officer on May 15, 1862. His ability was soon recognised, and in April 1866 he was given a command in the company's service, his first ship being the *Palmyra*. Among the many other vessels of the company which he subsequently commanded may be mentioned the *Sidon*, *Parthia*, *Algeria*, and *Scotia*. He remained Commander until 1882, when he was appointed General Superintendent, which responsible position he retained up to the time of his death.

Since 1882 the Cunard Company have added a large number of vessels to their fleet—the *Campania* and *Lucania* being the fastest steamers between Liverpool and America. All these ships were designed and built under the supervision of Capt. Watson. The arrangements in connection with the fitting of Cunard steamers as transports were in his hands, and so well was the work done that in September 1900 the Lords Commissioners of the Admiralty communicated to the Cunard Company their thanks for the valuable services rendered by him to their department.

Early in 1888 Capt. Watson was appointed by the Admiralty an Honorary Commander in the Royal Naval Reserve. Few companies have had the happiness to possess so able and faithful a servant, and his

loss will be keenly felt by every one connected with the Cunard Line.

He died on January 22, 1902.

He was elected a Fellow of this Society on February 20, 1878.

HEINRICH VON WILD was born near Zürich on December 17, 1833. After studying at Zürich, Konigsberg, and Heidelberg, he was appointed, at the early age of 25, Professor of Physics in the University and Director of the Observatory at Berne, in succession to Prof. Wolf. He developed great activity in that post, and made the Observatory the central station for the Swiss Meteorological Service.

In 1867 he was invited to become Director of the Central Physical Observatory at St. Petersburg, in succession to Prof. Kämtz, and his twenty-seven years' service in that important post exhibits constant and uninterrupted progress.

Prof. Wild's contributions to meteorological literature have been very numerous. In 1869 he founded the *Repertorium für Meteorologie*, which was a high-class meteorological publication. He carried out numerous experimental observations on various subjects, and as the result he introduced improvements in several instruments, among which were the metal thermometer screen, the siphon barometer, and the pressure-plate anemometer. He also published elaborate discussions on the temperature and climate of Russia.

Prof. Wild took great interest in the endeavours to promote uniformity in the methods of observation, and he was for some years President of the International Meteorological Committee.

He retired from Russia in 1895, and spent the rest of his life at Zürich, where he died on September 5, 1902.

He was elected an Honorary Member of this Society on June 17, 1874.

APPENDIX IV.

BOOKS PURCHASED DURING THE YEAR 1902.

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LANTERN SLIDES.

Climate of Cyprus (3 slides).
Eclipse Cyclone (3 slides).
Lightning Flashes and Damage by Lightning (9 slides).

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1902.

BOOKS AND PAMPHLETS.

Presented by Societies, Institutions, etc.

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APPENDIX VI.

REPORTS OF OBSERVATORIES, ETC., FOR 1902.

THE METEOROLOGICAL OFFICE.—W. N. Shaw, D.Sc., F.R.S., Secretary.

In the Marine Branch the issue of Monthly *Pilot Charts* for the North Atlantic and Mediterranean has been continued. Inset charts of means of temperature over the Atlantic, for the month next but one before the month of issue, have been introduced. Owing to the effective co-operation of the captains and officers of the ships contributing the returns, it has been found possible to prepare charts, from time to time, illustrating any striking meteorological occurrences that have been recorded. The amount of miscellaneous information of this kind included in recent issues of the charts has been considerably increased. The arrangements for the sale of the charts to the public have been modified; they can now be obtained from the agents for the sale of Admiralty publications. The price remains unaltered, viz. 6d. for a single chart, or 5s. for a series of twelve, exclusive in each case of the charge for postage. Captains and officers of the Mercantile Marine can obtain them, as heretofore, from the Mercantile Marine Offices at the principal ports of the United Kingdom.

The volume of *Monthly Wind Charts* with isobars for the Coastal Regions of South America, which has been in preparation for some years, has been issued by the Hydrographic Department of the Admiralty. The corresponding charts for the Southern Ocean have been completed and are nearly ready for issue. The preparation of a series of meteorological charts for the Indian Ocean has been commenced.

In the work of the Telegraphic Branch few changes have taken place since the end of June. Map IV. of the *Daily Weather Report* has been utilised to exhibit the average daily duration of sunshine for each month at a number of stations, alternately with the mean daily temperature for the month, obtained from the average of the daily maximum and minimum temperatures. The latter is introduced for the purpose of comparison with the mean monthly temperature at 8 a.m. which is shown in Map V.

The courtesy of the Commercial Cable Company has enabled the Council to avail themselves of the recent development of the Meteorological organisation at the Azores under Captain Chaves. From the beginning of December a daily telegram has been forwarded to the Office, without charge, reporting observations at 6 a.m. (with those of 9 p.m. of the previous day added) from Horta (Fayal). The daily telegram from Ponta Delgada (Sao Miguel) has in the meantime been continued through similar courtesy on the part of the Eastern Telegraph Company.

Upon the application of the Council, at the request of the Bureau Central Météorologique of Paris, arrangements have been made by the Government of Malta, and the Eastern Telegraph Company, at the instance of the Colonial Office, for the transmission of a daily telegram from Malta to Paris for the use of the *Bulletin International.*

In the Land Branches, the self-recording instruments at the Observatories have been maintained as heretofore. A Dines anemometer has been established at Pendennis Castle, Falmouth, in charge of the coastguard officer there. The instrument is more fully exposed than the Robinson anemometer at the Observatory.

A Halliwell rain-gauge with a very open scale has been temporarily installed on the roof of the Office, being lent for trial.

A self-recording mercurial barometer designed by Mr. Dines, and originally ordered to be lent for use in connection with the kite observations at Crinan,

has been set up in the Office for comparison with occasional readings of a standard barometer.

The volume of *Hourly Means* for each five days of observations at the self-recording Observatories for 1899 has been issued. The form of publication of these observations is now under revision.

The volume of *Temperature Tables* of the British Isles has been issued; a short Supplement has also been prepared and issued. The Supplement is intended to provide observers with the means of computing the thirty years' means for any station, from a comparison of the means for shorter periods with those of neighbouring stations for which thirty years' averages exist.

In 1902 a considerable change was introduced into the Monthly Summary of the *Weekly Weather Report*. The Summary, which has been continued for a long series of years, gives monthly statistical results, based on observations at 8 a.m., at the telegraphic reporting stations. These are with few exceptions on the coast, and do not necessarily represent the climatology of inland districts. The summaries have accordingly been supplemented by those obtained from 9 a.m. observations at a number of Normal Climatological Stations (Second Order Stations of the International Classification), the observers having very kindly forwarded the monthly tables immediately upon the close of the month. The general summary is thus made much more effective. Its issue has also been accelerated; it has appeared generally within a month of the period of observations. Some minor changes in the form of the report have been introduced.

The volume of results of observations at Normal Climatological Stations for 1899 has been prepared and issued.

In the course of the year it was intimated that Mr. J. Glaisher, on account of his very advanced age, was intending to relinquish the preparation of the meteorological information for the Registrar-General's Report, which had been in his hands for upwards of fifty years, and the Council were requested to prepare the information from the end of the first quarter of the year. After consultation with representatives of the Scottish Meteorological Society, which prepares the corresponding returns for Scotland, and the Royal Meteorological Society, and with Sir J. W. Moore, it was decided to recommend a practically common form for the Monthly Summaries of the observations for the Registrars-General of the three kingdoms. This form will come into use for the first quarter of 1903, and at the same time an effort will be made to select from all the available stations a number, which will represent the climatological conditions of the various types of locality, for the purpose of the Registrar-General. It is also proposed to include observations of earth temperatures with the meteorological returns.

The inquiry into the occurrence and distribution of fog in London was continued through the winter of 1901-02 by Captain Carpenter, R.N. It was reopened for the winter of 1902-03 under the superintendence of Mr. R. G. K. Lempfert, Captain Carpenter being obliged to withdraw from the investigation on account of his health. Captain Carpenter's report upon the observations in the first winter have been printed and issued as a separate publication. A report upon the whole inquiry will be made in due course. It is to be regretted that the inquiry must be now discontinued, the London County Council having decided not to grant funds for its further continuance.

Among other subjects of public interest dealt with in the course of the year may be mentioned arrangements for observations of cirrus clouds for the Norwegian Polar Expedition, the supply of meteorological instruments to the Scottish Antarctic Expedition and to the Committee for Kite Observations at Crinan.

The Council have been particularly requested to arrange for nephoscopic

observations in connection with the International Balloon Ascents in the current year, and they hope to deal with the matter in the ensuing year.

The Council have been informed that the International Meteorological Committee has decided to hold its next meeting at Southport in September 1903, during the Session of the British Association.—*April* 15, 1903.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, C.B., M.A., F.R.S., Astronomer-Royal.

The meteorological observations by eye, and by self-recording instruments, have been maintained as usual, and the special observations of clouds on selected days in each month have been continued at the request of the International Balloon Committee.

The temperature of the air ranged between 86°·1 on July 14, and 14°·3 on February 16. The annual mean temperature was 49°·1, being 0°·4 below the average. The monthly mean temperatures in January and March exceeded their averages by 3°·5 and 2°·9 respectively; in February and May they were below their average values by 4°·1 and 4°·5. The sunshine recorded in the year amounted to 1228 hours out of a possible duration of 4459 hours, giving a percentage of 27 for the year. The year was unusually cloudy, and there were 86 sunless days. The total amount of sunshine was 338 hours less than the amount recorded in 1901. Rain fell on 159 days in the year to the total amount of 19·337 ins., being 5·201 ins. less than the average for the 50 years 1841-90. In the 8 years 1895-1902 the deficiency of rainfall amounts to 28·906 ins.—*March* 7, 1903.

ROYAL OBSERVATORY, EDINBURGH.—R. Copeland, Ph.D., F.R.S.E., Astronomer-Royal for Scotland.

The meteorological observations have been carried on during 1902 by the staff of the Observatory as in previous years, no additions having been made to the instruments in use. All the thermometers were tested in melting ice in March. A monthly copy of the readings has been supplied as formerly to the Secretary of the Scottish Meteorological Society, and the monthly means have been published, along with similar results from a large number of other stations in Scotland, in the Quarterly Reports of the Registrar-General for Scotland. Weekly returns of temperature and rainfall have also been furnished to the Registrar-General, and a summary of wind velocities, as shown by the self-recording Robinson anemometer, along with the amount of bright sunshine and rainfall, has been supplied to the *Scotsman* newspaper for publication.

The number of hours of sunshine amounted to 1180 for the year, or 26·4 per cent of the possible duration. This was 414 hours, or 9·3 per cent of the possible, less than the number recorded in 1901. April showed the highest percentage, 38 of the possible, and December the lowest, 15 per cent. The rainfall for the year was very deficient, more especially in the months of January, February, March, and November, amounting to only 16·442 ins. in the twelve months, as compared with 22·702 ins. in 1901.—*February* 2, 1903.

NATIONAL PHYSICAL LABORATORY (KEW OBSERVATORY), RICHMOND, SURREY.—R. T. Glazebrook, D.Sc., F.R.S., Director; Charles Chree, LL.D., F.R.S., Superintendent of Observatory Department.

The several self-recording instruments have been maintained in regular operation throughout the year, and the standard eye observations for the control

of the automatic records have been duly registered. The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

On the initiative of the Meteorological Office, some special cloud observations have been made in connection with the International scheme of balloon ascents. Extra observations have also been made, when possible, of "upper clouds," in connection with the Norwegian polar investigations being carried out by Prof. Birkeland.

Electrograph.—This instrument worked generally in a satisfactory manner during the year. In July, all parts of the instrument were thoroughly cleaned, and in December the "Mascart" insulators were dismounted, cleaned, fresh acid added, and the ebonite supports coated with paraffin wax. Small alterations have been made to the down pipe, to improve the insulation. Scale value determinations were made on April 7, July 18, and December 12; and the potential of the chloride of silver battery has been tested fortnightly. Forty cells have been employed, giving about 30 volts.

A series of curves—usually 10 a month—have been selected as representative of the variations of potential on electrically "quiet" days, defined as days when irregular fluctuations of potential are fewer than usual. These curves have been tabulated, and the results appear, with the permission of the Meteorological Office, in the annual *Report*. Owing presumably in large measure to the fewness of the selected days, the values deduced from the actual curve measurements show in some months a considerable non-cyclic element. The value of this is explicitly stated with a view to possible future use. This element has been eliminated from the diurnal inequality in the way customary in dealing with meteorological data.

Atmospheric Electricity.—The comparisons of the potential, at the point where the jet from the water-dropper breaks up, and at a fixed station on the Observatory lawn, have been continued, and the observations have been taken on every day when possible, excluding Sundays and wet days. The ratios of the "curve" and the "fixed station" readings have been computed for each observation, and these throw considerable light upon the action of the self-recording electrometer, especially in reference to the insulation problem.

Since January 1, a new fixed stand has been used, instead of the older station. The new stand consists of a stout brass tube, down which a brass rod slides. The rod carries a small table just large enough to take the portable electrometer, furnished with guard pins to prevent the instrument being accidentally knocked over. The rod can be clamped at any point, so that even in case of heavy snow, the distance between the electrometer and the surface beneath could be kept constant.

A series of observations were made on the new and on the old stone stand to establish a connection between the results obtained at the two stations. The new stand has also been used for observing the potential at three different heights, viz. 125 cm., 150 cm., and 175 cm. above the ground.

Observations on the loss of positive and negative electrical charges have been made with a "dissipation apparatus" of Elster and Geitel's pattern. Usually the loss of charge has been very slow, and the apparent differences in the state of insulation of the apparatus before and after the proper dissipation experiment have introduced an undesirably large element of uncertainty. The results are meantime withheld pending further experience.

Fog and Mist.—The observations of a series of distant objects, referred to in previous Reports, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour. At the request of the Meteorological Council, extra observations of surface fog and darkness

have been made in connection with the investigation of London fogs, undertaken by the Office and the London County Council.

Seismological Observations.—Prof. Milne's "unfelt tremor" pattern of seismograph has been maintained in regular operation throughout the year. The largest disturbances recorded took place on September 23, when the maximum amplitude exceeded 17 mm.; on September 22, when the maximum was 8·5 mm.; and on April 19, when the maximum amplitude was 7 mm. A detailed list of the movements recorded from January 1 to December 31, 1902, has been made, and will be found in the *Report of the British Association* for 1903, "Seismological Investigations Committee's Report."

Sunshine Recorder.—It having been observed that the card in the present standard pattern of the Campbell-Stokes sunshine recorder is situated well inside the focus of the spherical lens, experiments have been made as to whether this is the best arrangement. Messrs. Chance Brothers, on being applied to, constructed and lent for experiment a sphere of the standard glass, of less than the normal dimensions, and a series of observations have been taken with this, employing a bowl of normal dimensions lent by the Meteorological Office. Further experiments are being made.

The mean temperature for the year was 49°·2, which is 0°·1 lower than the average for the 30 years 1871-1900. The extremes ranged from a maximum of 83°·0 on July 14 to a minimum of 17°·7 on February 16. The highest mean monthly value was 60°·8 in July, and the lowest was 35°·8 in February.

The following table gives the differences of the mean monthly temperatures from the corresponding mean values for the 30 years 1871-1900:—

January	+3°·3	May	−3°·2	September	−0°·8
February	−4·1	June	−0·8	October	+1·0
March	+2·8	July	−1·5	November	+1·1
April	+0·3	August	−1·8	December	+2·3

The maximum temperature in the sun's rays (black bulb *in vacuo*) was 139° on July 5, and the minimum temperature on the ground was 4° on February 16.

The mean percentage of bright sunshine, as registered by the Campbell-Stokes recorder, was 27 (old style) and 30 (new method) (see *Quarterly Journal Roy. Met. Soc.* vol. xxviii. p. 209). This is the lowest mean value since 1889, and with the exception of January, July, and September, every month was below the average, the deficit being most marked in August, which, with a value of 28 per cent, is 12 per cent below the average. This is, in fact, the lowest amount yet recorded for that month. The highest monthly percentage was 43 in September.

The rainfall for the year amounted to 21·425 ins., which is 2·44 ins. below the average for the past 40 years. The heaviest monthly total was 3·705 ins. in June, being 1·58 ins. above the average for that month, and the largest fall since 1879. The minimum fall was 0·560 in. in April, being 0·95 in. below the average for that month.—*March* 26, 1903.

RADCLIFFE OBSERVATORY, OXFORD.—Arthur A. Rambaut, M.A., D.Sc., F.R.S., Radcliffe Observer.

The meteorological observations and automatic registrations have been maintained as usual, and the results have been regularly sent as heretofore to the Meteorological Office (by daily telegram), the Registrar-General, the Thames Conservancy, the local newspapers, and to sanitary and public authorities upon request, as well as to some private inquirers. The five underground platinum resistance thermometers have been in use throughout the year. The new switchboard with copper blocks, and the new leads of continuous copper cord,

mentioned in last year's report, have proved much more reliable than those they superseded. The copper cord, however, has shown some occasional effects of torsion when twisted through 360° for reversal tests; but the causes of these very slight changes, which are difficult to trace, have not yet been clearly defined.

The annual inspection of the automatic instruments, and comparisons of the thermometers with a Kew standard, and the barometer with a travelling standard barometer, were made by Mr. Constable of the Kew Observatory with very satisfactory results. The thermometers have also been independently checked for zero point in melting snow. Two new rain-measure glasses, and all the old ones in use, have been carefully tested by weighing known quantities of water as a check on the graduations etched upon the glass, to secure approximate accuracy in reading to the thousandth of an inch.

The following are the chief characteristics of the weather noted at Oxford in the year 1902:—

The mean reading of the year for the barometer was 29·744 ins., being 0·018 in. above the mean for the preceding 47 years. The highest reading was 30·640 ins. on January 15; the lowest reading was 28·714 ins. on December 30, showing an annual range of 1·926 in.

The mean temperature of the air was 48°·6, being 0°·2 below the average deduced from the preceding 74 years. The maximum temperature occurred on July 14, when 83°·6 was recorded; the minimum was 18°·7 on February 17, and on the grass, 13°·4 on the same date.

The differences of the mean monthly temperatures from the corresponding means for the preceding 74 years were:—

	°		°		°
January	+3·4	May	−4·0	September	−0·3
February	−4·3	June	−1·1	October	+0·4
March	+3·2	July	−1·2	November	+1·6
April	−0·1	August	−1·3	December	+1·2

Bright sunshine in 1902 amounted to 1371 hours, or 94 hours below the mean for the previous 22 years. The monthly departures from the mean were:—

	hrs.		hrs.		hrs.
January	+20	May	−25	September	+17
February	−1	June	−18	October	−29
March	−21	July	0	November	−3
April	+25	August	−59	December	0

Rainfall in the year amounted to 18·056 ins., or 8·031 ins. below the mean for the preceding 87 years. The monthly amounts are all in defect as follows:—

	in.		in.		in.
January	−1·206	May	−0·131	September	−1·424
February	−0·540	June	−0·126	October	−1·205
March	−0·213	July	−1·883	November	−0·078
April	−0·526	August	−0·096	December	−0·603

The rainfall during 1902 is the lowest annual record since 1870 (17·564 ins.): it has only been approached within recent years by 1890 (18·412 ins.) and 1893 (18·607 ins.).

It may be interesting to add that at Oxford the deficiency of rainfall during the last 11 years amounts to no less than 35·596 ins., whilst of this 23·011 ins. are due to the deficiencies of the last 5 years (1898-1902).—*February* 6, 1903.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 18, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

ALFRED ERNEST ABBOTT, Wolverton ;
BENJAMIN PRESELLY EVANS, Treharris, Glamorgan ;
LEON TEISSERENC DE BORT, 82 Avenue Marceau, Paris ; and
ALFRED FRANCIS WATERHOUSE, 3 Lewes Crescent, Brighton,
were balloted for and duly elected Fellows of the Society.

Mr. C. V. BOYS, F.R.S., gave a Lecture on "THE PASSAGE OF SOUND THROUGH THE ATMOSPHERE," which was illustrated by experiments and lantern slides (p. 145).

April 15, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

JOHN RICHARD SUTTON, M.A., Kenilworth, Kimberley, South Africa, was balloted for and duly elected a Fellow of the Society.

The following communications were read :—

1. "THE PREVALENCE OF GALES ON THE COASTS OF THE BRITISH ISLANDS, 1871-1900." By FREDERICK J. BRODIE, F.R.Met.Soc. (p. 151).
2. "THE DURATION OF RAINFALL." By JOSEPH BAXENDELL, F.R.Met.Soc. (p. 181).

CORRESPONDENCE AND NOTES.

Greatest Variations of Temperature.—Having recently been asked for some particulars as to the greatest variations of temperature in 3 and 7 days, I think that the information obtained is of sufficient interest for insertion in the *Quarterly Journal*.

The records searched were chiefly the Second Order and the Climatological returns of the Royal Meteorological Society. The temperatures are those recorded by thermometers in Stevenson screens.

Highest Temperature.

97°·1 at Uppingham, August 14, 1876.

Lowest Temperature.

- 11°·1 at Buxton, February 11, 1895.

Greatest Variations in 3 Days.

January 1901	Swarraton	9th min.	-1°9,	10th max. 49°2	51°1
February 1895	Buxton	11th min.	-11·1,	14th max. 34·0	45·1
March 1893	Cambridge	29th min.	26·0,	29th max. 70·0	44·0
April 1893	Cambridge	20th max.	84·0,	22nd min. 39·0	45·0
May 1895	Aspley Guise	29th min.	37·5,	30th max. 85·6	48·1
June 1893	Marlborough	19th min.	45·0,	19th max. 85·5	40·5
July 1876	Hillington	12th min.	44·9,	14th max. 89·1	44·2
August 1887	Marlborough	3rd min.	36·0,	4th max. 86·5	50·5
September 1895	Loughborough	22nd min.	32·0,	24th max. 86·0	54·0
October 1890	Hodsock	12th max.	70·5,	13th min. 28·5	42·0
November 1890	Beddington	28th min.	2·3,	30th max. 37·1	34·8
December 1891	Aspley Guise	25th min.	12·0,	26th max. 45·0	33·0

Greatest Variations in 7 Days.

January 1894	Hodsock	6th min.	-4°4,	11th max. 53°0	57°4
February 1889	Beddington	12th min.	8·5,	17th max. 57·8	49·3
March 1890	Beddington	4th min.	5·4,	7th max. 52·9	47·5
April 1893	Cambridge	14th min.	24·0,	20th max. 84·0	60·0
May 1895	Aspley Guise	29th min.	37·5,	30th max. 85·6	48·1
June 1893	Marlborough	13th min.	40·3,	19th max. 85·5	45·2
July 1876	Strathfield Turgiss	12th min.	42·1,	15th max. 91·3	49·2
August 1887	Marlborough	3rd min.	36·0,	4th max. 86·5	50·5
September 1895	Loughborough	22nd min.	32·0,	24th max. 86·0	54·0
October 1897	Marlborough	13th min.	29·2,	17th max. 73·2	44·0
November 1890	Beddington	23rd max.	58·2,	28th min. 2·3	55·9
December 1891	Aspley Guise	25th min.	12·0,	30th max. 52·5	40·5

It is not supposed that the above, which apply only to England, are by any means complete, but they are only such as have been found in a cursory examination of the returns. WILLIAM MARRIOTT.

Snow Crystals.—The Annual Summary of the United States *Monthly Weather Review*, 1902, contains a most interesting and valuable paper by Mr. W. A. Bentley on his studies among the snow crystals during the winter of 1901-2. For 20 years Mr. Bentley has devoted himself to the study of snow crystals. His collection of photomicrographs taken at Jericho, Vt., surpasses the sum total of all that has been done by all others in the world. The paper is illustrated by 255 beautiful photomicrographs of snow crystals.

Mr. Bentley's remarks on the structure of snow crystals are as follow :—"The beautiful details, the lines, rods, flowery geometrical tracings, and delicate symmetrically arranged shadings to be found within the interior portions of most of the more compact tabular crystals, and in less degree within the more open ones, have attracted the attention of nearly all observers who have studied snow crystals. That these interior details more or less perfectly outline pre-existing forms must have been early recognised, yet the knowledge as to what they actually were remained long in obscurity, and a complete explanation of all of them is yet to be found. The investigations of Dr. Nordenskiold and Dr. G. Hellmann enable us to form a general conception as to their true character. These observers discovered that many of the lines, rods, and other configurations within the crystals, that add so much to the beauty of the forms, and which are so plainly revealed in the photomicrographs, are due to minute inclusions of air. This included air prevents a complete joining of the water molecules; the walls of the resultant air tubes cause the absorption and refraction of a part of the rays of light entering the crystal; hence, those portions appear darker by transmitted light than do the other portions. The softer and broader interior shadings may perhaps also be due, in whole or part, to the same cause, but if so, the corresponding inclusions of air must necessarily be much more attenuated

and more widely diffused than in the former cases. We can only conjecture as to the manner in which these minute air tubes and blisters are formed. It may well be that some of them are the result of a sudden and simultaneous rushing together of water molecules around the crystal from all sides. This might result in the formation of closely contiguous parallel ledges, or laterally projecting outgrowths that are separated from each other during the initial impact by a narrow groove, or air space, but are soon bridged over by subsequent growth. Similar contiguous parallel growths occur frequently around the angles of very short columnar forms, and lend plausibility to this theory. Air spaces also exist within columnar forms, as noted by Hellmann and Nordenskiold. They seem to occur within such forms as hollow cup-like extensions, projecting perpendicularly within them from each of the ends of the crystals. Their presence is strongly indicated in some of the photomicrographs of such forms illustrating the article."

Egyptian Meteorology.—Steps have been taken during the last few years to secure systematic meteorological observations from various parts of Egypt. The Government Observatory at Abbassia, Cairo, has been reorganised, and Mr. H. G. Lyons appointed Director-General. Self-recording instruments have been installed, including a Dines pressure-tube anemometer. The hourly tabulations for the year 1900 have just been published.

Meteorological stations have been equipped at Abbassia, Alexandria, Assiut, Aswan, Berber, Duem, Giza, Khartum, Omdurman, Port Said, Suakim, Wadi Halfa, and Wadi Medani, and the observations are printed on monthly sheets.

A system of telegraphic daily weather reports was commenced on May 1, 1900. The observations are reduced and lithographed at the Survey offices, and are issued by noon daily. Later, by the liberality of the Eastern Telegraph Company, it has been possible to arrange with the Meteorological Services of Malta, Italy, Austria, and Greece for the daily interchange of morning telegrams.

Climate of Alexandria.—Meteorological observations have been made at Alexandria for a number of years. The results for the ten years 1891-1900 are given in the *Report on the Meteorological Observations* made at the Abbassia Observatory, Cairo, 1900, from which the following brief summary has been compiled:—

Month.	Temperature.			Relative Humidity.	Rainfall.	
	Mean.	Highest.	Lowest.		Amount.	No. of Days.
	°	°	°	%	ins.	
January	57·4	77·0	41·6	61·5	2·13	11·7
February	58·7	85·5	43·1	61·1	·88	6·9
March	61·1	98·7	41·8	60·8	·66	6·0
April	65·2	102·0	51·9	62·4	·09	1·0
May	70·4	102·0	56·0	65·2	·05	0·7
June	75·2	103·0	56·9	69·3	...	...
July	79·0	98·7	68·8	70·3	...	...
August	79·9	95·0	68·5	67·6	...	...
September	78·0	104·0	65·6	65·4	·03	0·2
October	74·7	100·0	59·0	66·4	·35	1·8
November	68·0	90·0	51·5	62·7	1·50	7·3
December	61·0	84·0	44·1	65·1	3·17	11·0
Year	69·0	104·0	41·6	64·8	8·86	46·6

Climate of the East Africa Protectorate.—In a paper on "Colonisation and Irrigation in the East Africa Protectorate" recently read before the Royal

Geographical Society, Mr. R. B. Buckley said that the climate of the East Africa Protectorate varies with the elevation of the lands above the sea. The country lies almost entirely within 4° north or south of the equator, and it is difficult to realise that in the very heart of the tropics a climate can be found which is so pleasant as that which actually exists in a considerable area of it. Near the coast the thermometer rarely falls below 70°, and it rarely rises above 90°; the monthly mean of the maximum temperatures in Mombasa in the coolest months (March and April) is about 89° or 90°, and the monthly mean of the minimum temperatures is about 70° or 71°. In these parts the climate is damp and enervating. But in the higher lands, say those which are 5000 ft. or more above the sea, the climate is very different; the thermometer rarely rises above 80°, and often falls below 60°. The returns at Machakos and Fort Smith (5000 to 6000 ft. above the sea) show that the monthly mean of the maximum temperatures is rarely more than 70°, although the actual maxima for short intervals are of course higher, and that the monthly mean of the minimum temperatures is rarely above 60°, and it falls at times as low as 50° or even 40°. This is the part of the country where the white man might live and flourish.

The rainfall, which is such an important factor as regards the agricultural prospects of the country, may be said to average about 40 ins. in the year at the coast, and about 36 ins. in the lands lying at a higher elevation than 5000 ft. On the banks of Victoria Nyanza, at a level of about 3700 ft. above the sea, the rainfall is greater, and it averages from 50 to 70 ins. in the year. The following statement is taken almost entirely from the *Report of the British Association*, 1901 (p. 395):—

Year.	Coast.						Inland.				
	Kisimayu. 0° 22′ S. by 42° 3′ E.	Malindi. 3° 13′ S. by 40° 7′ E.	Lamu. 2° 16′ S. by 40° 5′ E.	Takaunga. 3° 41′ S. by 39° 5′ E.	Mombasa. 4° 4′ S. by 39° 4′ E.	Chuyu and (Wanga) Shimoni. 4° 6′ S. by 39° 3′ E.	Kibwezi. 2° 25′ S. by 37° 5′ E.	Machakos. 1° 31′ S. by 37° 2′ E.	Fort Smith (Kikuyu). 1° 14′ S. by 36° 4′ E.	Munia's Kavirondo. 0° 20′ N. by 34° 3′ E.	Nairob.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1890	...	...	29·0	...	34·7	...	...	...	...	...	...
1891	...	42·0	...	...	46·6	...	...	...	...	...	...
1892	...	30·1	...	32·1	26·4	...	...	...	...	...	...
1893	...	50·8	44·5	40·7	64·2	66·3	...	...	53·0	...	...
1894	13·7	28·9	21·1	38·0	38·0	42·0	26·7	42·0	48·1	...	...
1895	...	34·9	...	35·7	34·3	38·5	33·1	...	65·0	...	...
1896	19·5	53·6	41·3	47·8	65·2	56·6	21·7	25·9	29·5	58·8	...
1897	19·9	58·0	32·3	54·4	52·6	56·7	21·5	31·7	36·3	93·5	...
1898	10·9	14·4	12·4	24·0	25·0	27·3	...	24·3	36·2	69·1	...
1899	12·4	33·4	22·0	33·1	35·2	52·5	...	21·8	...	...	...
1900	12·9	37·0	...	58·1	61·7	59·8	...	58·3	...	50·0	42·4
1901	...	...	...	...	...	...	...	...	...	...	38·8
Average	14·9	38·3	28·9	40·4	44·0	50·0	25·7	34·0	44·6	67·8	40·6

The monthly rainfall statistics of the places included in the above table show that near the coast the South-west monsoon causes heavy rain in April and May, some 20 to 30 ins. falling usually during these months; light falls occur from June to October, and in November the fall is generally heavier; December to March are dry months. In the higher land, above 5000 ft., the heaviest falls are usually in March, April, and May; a dry season follows from

June to October, when there is usually a second period of rain in November or December.

Falls of more than 5 ins. in twenty-four hours appear to occur very rarely; falls of more than 4 ins. are not frequent. The records which exist are about to be supplemented by the institution of rainfall stations along the railway at intervals of about 40 miles. It seems most desirable that the meteorological observations of the Protectorate should be digested and tabulated on some authorised system; at present the records are not kept in a uniform manner, and are not readily accessible. They are very important.

RECENT PUBLICATIONS.

Aus dem Archiv der Deutschen Seewarte. XXV. Jahrgang, 1902. Hamburg, 1902. 4to. viii. + 143 pp. and chart.

The volume contains the following papers:—"Ueber die Anordnung der Nadeln einer Kompassrose zur Vermeidung der sextantalen und oktantalen Deviation": von Prof. Dr. C. Börgen (25 pp.).—"Ueber eine neue 'kimmfreie' astronomische Standlinie": von Dr. Carl W. Wirtz (8 pp.).—"Definitive Bestimmung der Bahn des Kometen 1899 I. (Swift)": von A. Wedemeyer (44 pp.).—"Ergebnisse von Sextantenprüfungen an der Deutschen Seewarte": von Dr. J. B. Messerschmitt (48 pp.).—"Neubearbeitung der nordatlantischen Wetterausschau Dampferkarte für Februar und März 1902": von Dr. von Neumayer (7 pp. and chart).

Handbook of Climatology. By Dr. JULIUS HANN. Part I. *General Climatology.* Translated, with the Author's permission, from the second revised and enlarged German edition, with additional references and notes by ROBERT DE COURCY WARD, Assistant Professor of Climatology in Harvard University. New York: The Macmillan Company. London: Macmillan & Co., Ltd. 1903. 8vo. xiv. + 437 pp. Price 12s. 6d.

This translation was undertaken primarily that it might serve as a text-book in the course of General Climatology in Harvard University. Mr. R. de C. Ward also hopes that the publication of an English edition of the standard work on climate will lead to the extension and improvement of the teaching of scientific climatology in the United States, as well as in Great Britain and her Colonies. The second edition of Dr. Hann's *Handbuch der Klimatologie* was published in 3 volumes in 1897. The first volume of that edition is the one included in the present translation. This concerns general climatology, and is a work complete in itself. Mr. Ward has found it impracticable to translate the last two volumes, which deal with special climatology.

As a notice of the second edition of Dr. Hann's *Handbuch der Klimatologie* appeared in the *Quarterly Journal*, vol. xxiv. p. 52, it will merely be necessary to give in brief the headings of the various chapters.

PART I. THE CLIMATIC FACTORS.
Introduction. Climatology: Its Meaning, Aims, and Methods.
Chap. 1. Temperature.
„ 2. The Moisture of the Atmosphere: Humidity, Precipitation, and Cloudiness.
„ 3. Winds, Pressure, and Evaporation.
„ 4. The Composition of the Atmosphere.
„ 5. Phenological Observations.
PART II. GENERAL CLIMATOLOGY: Solar Climate and the Chief Varieties of Physical Climate.

Mr. Ward states that practically all of the important publications which have been issued since the completion of the second German edition are referred to in the present volume, and he has added some new examples of different climatic phenomena, chiefly from the United States. Every change that has been made has been approved by Dr. Hann, who was consulted in all such matters.

It would have been of great advantage to British meteorologists if the translator had made use of English measurements, instead of employing exclusively the centigrade and metric systems.

Jahrbuch des Norwegischen Meteorologischen Instituts für 1902. Herausgegeben von Dr. H. Mohn. Christiania, 1903. 4to. xii. + 122 pp.

In addition to an Introduction by Dr. Mohn, this contains the hourly readings at Christiania, the daily observations at 12 Second Order stations, and the monthly results at 50 stations in Norway for the year 1902.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. March—May 1903. 4to.

The principal articles are:—"Zum Klima von Sofia": von Dr. A. Ischirkoff und C. Kassner (3 pp.). This is an elaborate paper by two authors, Dr. Ischirkoff of Sofia and C. Kassner of Berlin, and is divided into three parts: first the general temperature, then the daily range of temperature, and finally ten year means for the station.

"Die atmosphärische Elektrizität auf Grund der Elektronentheorie": von Prof. Hermann Ebert (8 pp.). This is a lecture delivered at the Meeting of the Swiss Naturforscher Versammlung in Geneva, 1902.

"Zum Klima von Südchile, Llanquihue, und Chiloe": von Dr. C. Martin (9 pp.). This is a very interesting paper. It is hardly possible to distinguish between the seasons. The climate is very damp. It is remarkable that the maximum temperature rises higher above the mean than the minimum sinks below it.

"Die Szintillation der Fixsterne vom Standpunkt der synoptischen Meteorologie": von E. Rosenthal (12 pp.). The question of utilising the scintillation of the stars in weather forecasting has been put forward from time

to time by Montigny and others, and now Herr Rosenthal has given a careful treatment of the subject. He utilised the double star observations of Glasenapp, made partly at St. Petersburg, but mostly at a station some 80 miles to the southward of that observatory. These latter observations are particularly good, as there is no interference of smoke with the clearness of the atmosphere. The observations of clearness of definition are given according to metrical scale and then arranged according to the types of weather, the least scintillation (Class I.) corresponds to a neutral condition, the greatest (Class III.) to a strongly marked cyclonic type of weather. The double star observations are selected owing to their great delicacy.

"Zum Klima des Staates Ceará, Brasilien.—II. Quixadá": von F. M. Draenert (7 pp.). This is another of Prof. Draenert's useful contributions to our knowledge of the meteorology of Brazil. This place is situated in 5° S. One of the remarkable features of its climate is its unusual dryness for a tropical district, which brings about its extraordinary salubrity.

"Über die Ausmessung meteorologischer Photogramme": von G. Grundmann (7 pp.). This is a mathematical treatment of the measuring of photographs of halos, etc.

"Über Temperaturschwankungen auf hohen Bergen": von M. Margules (22 pp.). This is a careful investigation of twelve special sequences of weather, during which very considerable oscillations of temperature were noticed at the Sönnblick. The paper is so full of details that a satisfactory abstract cannot well be prepared.

Observatoire Royal de Belgique. Annuaire Météorologique pour 1903, *publié par les soins de* A. LANCASTER. Bruxelles, 1903. Small 8vo. 7 + 662 pp.

During the past sixty-seven years the Observatoire Royal has regularly published an *Annuaire* devoted to the sciences of Astronomy and Meteorology. Since 1901 each of the services has issued its own *Annuaire*. The present volume is the third issued by the Meteorological Service, and contains, in addition to the usual information, the following articles:—"Aperçu de l'histoire de la météorologie en Belgique": par J. Vincent, Troisième Partie (94 pp.). The first and second parts of this History have appeared in the previous *Annuaire*. This third part deals with the period from the foundation of the Observatoire Royal by Quetelet till the reorganisation of that establishment by Houzeau.—"Étude sur la marche des cirrus dans les cyclones et les anticyclones d'après les observations faites à Uccle": par E. Vanderlinden (65 pp.).—"La force du vent en Belgique": par A. Lancaster (133 pp.).—"Notes bibliographiques sur les nuages (classification et nomenclature)": par J. Vincent (20 pp.).—"Le climat de la Belgique en 1901": par A. Lancaster (188 pp.).

Report of the British Association for the Advancement of Science. London, 1903. 8vo. 118 + 924 + 112 pp. and 7 pl.

This volume contains the following reports and abstracts of meteorological papers read at the meeting of the Association at Belfast in September 1902:—

"Comparing and Reducing Magnetic Observations" (1 p.).—"Seismological Investigations" (17 pp. and pl.).—"Magnetic Observations at Falmouth" (1 p.).—"Investigation of the Upper Atmosphere by Means of Kites" (4 pp.).—"Meteorological Observations on Ben Nevis" (5 pp.).—"Bird Migration in Great Britain and Ireland" (11 pp.).—"Terrestrial Surface Waves and Wave-like Surfaces" (1 p.).—"Address to Section of Astronomy and Cosmical Physics": by Prof. A. Schuster (9 pp.).—"New Solar Radiation Recorder":

by Dr. W. E. Wilson (1 p.).—"Minimum Sunspots and Terrestrial Magnetism": by the Rev. A. L. Cortie (2 pp.).—"Radiation in Meteorology": by W. N. Shaw (1 p.).—"World-shaking Earthquakes in relation to Volcanic Eruptions in the West Indies": by J. Milne (1 p.).—"The Rainfall of Ireland": by H. R. Mill.

Report of the Meteorological Council, for the Year ending 31st of March 1902, *to the President and Council of the Royal Society.* London, 1902. 8vo. 163 pp. and map.

This Report is divided into seven parts, viz.—Ocean Meteorology, Weather Telegraphy and Forecasts, Climatology, Library, Miscellaneous Investigations, Publications, and Finance.

The following figures show the amount of success of Storm Warnings in the decade 1892-1901 :—

Years.	Total No. of Warnings issued.	Warnings justified by subsequent Gales.	Warnings justified by subsequent Strong Winds.	Total Warnings justified.	Warnings not justified by subsequent Weather.
		%	%	%	%
1892	488	59·4	31·2	90·6	6·8
1893	480	60·8	28·6	89·4	7·1
1894	502	68·5	23·5	92·0	6·0
1895	523	63·3	26·4	89·7	8·0
1896	467	67·7	23·8	91·5	2·9
1897	596	60·1	31·7	91·8	4·5
1898	581	59·8	27·5	87·3	4·5
1899	504	59·3	31·9	91·2	4·8
1900	512	66·2	25·8	92·0	6·3
1901	498	62·3	26·1	88·4	7·4

In the Appendix is given the correspondence with the London County Council with regard to an inquiry into the occurrence and distribution of Fogs in London.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest. For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

Allan, H. S.—A Regulating or Recording Thermometer. *Nature, London,* **68** (69-70).

Anderson, J.—The Kite Equipment of the Scottish National Antarctic Expedition. *Aëronautical Journal, London,* **7** (25-27).

Angot, A.—Sur le calcul des moyennes et la variabilité de la température en France. *Ann. Soc. Mét. France, Paris,* **51** (53-59).

Assmann [R.].—Aus dem Aëronautischen Observatorium. *Das Wetter, Berlin,* **20** (70-72).

Bacon, Rev. J. M.—Clouds as seen from Cloud Level. *Knowledge, London,* **26** (114-116).

Bentley, W. A.—Studies among the Snow-Crystals during the Winter of 1901-02, with additional data collected during previous winters. *Monthly Weather Review, Washington,* **30** (607-616 and 22 pl.).

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THE METEOROLOGICAL ASPECTS OF THE STORM OF FEBRUARY 26-27, 1903.

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with the assistance of R. G. K. LEMPFERT, M.A., and F. J. BRODIE, F.R.Met.Soc.

[Read June 17, 1903.]

Introduction.

BETWEEN sunset of February 26 and noon of February 27, 1903, the British Isles were visited by a storm of unusual severity. Its most impressive characteristic was the amount of damage done to trees and buildings by gales from the South or South-west, particularly in the neighbourhood of Dublin, where very large numbers of trees were uprooted, and in Lancashire. Gales or strong winds were also experienced in many other parts of the British Isles. The table on p. 234 gives the extreme values of wind measurements of various kinds that were reported to the Meteorological Office, together with the time of occurrence and the wind direction.

Considered from the meteorological standpoint, the phenomenon can only be regarded as an unusually energetic and therefore destructive example of a comparatively common occurrence, namely, the passage across our Islands of a barometric minimum with the usual circulation of winds around the centre. I have thought that I should comply most adequately with the request of the Council of the Society for a paper on this notable storm by using the information collected by the Meteorological Office to exhibit as fully as possible the meteorological aspects of the occurrence. I shall therefore not detain the Society with any detailed account of the havoc caused by the gales. Mr. W. D. Matthews has compiled for me, from the newspapers of the time, as complete a record as he

could of the destruction attributed to the wind and the casualties produced thereby, and from it Mr. Brodie has prepared the map Fig. 1 which shows the path of the barometric minimum and the area over which the destruction extended. It may be advisable to have the list of mishaps on record for the purpose of reference in the future; I have therefore included it as an appendix to this paper, which may be preserved in the archives of the Society.

WIND VELOCITIES FROM ANEMOGRAPH RECORDS.

Observatories.	Wind Direction.	Time of Occurrence.	Maximum Velocity Recorded.
Valencia . .	W.S.W.	Midt. 26th-1 a.m. 27th	63 miles in the hour.
Falmouth . .	S. by W.	,,	37 ,, ,,
,, . .	S. by W.	11.50 p.m., 26th	88 miles per hour, in squalls.
Armagh . .	S.S.E.	2-3 a.m., 27th	33 miles in the hour.
Kingstown . .	W.S.W.	4-5 a.m., 27th	66 ,, ,,
Holyhead . .	S.W.	5-6 a.m., 27th	52 ,, ,,
Southport . .	W.S.W.	6-7 a.m., 27th	65 ,, ,,
,, . .	W.S.W.	5.55 a.m., 27th	87 miles per hour, in squalls.
Stonyhurst . .	W.S.W.	6-7 a.m., 27th	43 miles in the hour.
Glasgow . .	W.	Noon-1 p.m., 27th	26 ,, ,,
Deerness . .	E.	7-8 a.m., 27th	36 ,, ,,
North Shields .	S.W.	7-8 a.m., 27th	70 ,, ,,
Aberdeen . .	S.E.	3-4 a.m., 27th	33 ,, ,,
Kew . . .	S.S.W.	3-4 a.m., 27th	32 ,, ,,
,, . . .	S.S.W.	4.7 a.m., 27th	59 miles per hour, in squalls.
Oxford . .	S.S.W.	3-4 a.m., 27th	34 miles in the hour.
Berkhamsted .	S.	2-3 a.m., 27th	23 ,, ,,

The map distinguishes between the destruction of trees, damage to buildings and other property on land, and damage to shipping. It ought to be noted that damage to structures is evidence of the comparative weakness of the structures, as well as of the force of the wind. It will be seen that reports of such occurrences came in greatest number from the thickly populated parts of Lancashire; it must not on that account be assumed that that region was the locality of maximum wind force.

Before turning to the meteorological aspects of this particular visitation, I wish to put forward some general considerations about barometric depressions and storms which will indicate the point of view from which I have approached the consideration of the subject.

The occurrence of a specially intense example of a revolving storm can hardly fail to remind us that these phenomena, common as they are in their less acute forms in these Islands and over the Atlantic, are still somewhat mysterious. Much was written about them before Dove attributed their occurrence to the play of conflicting currents, and much has been written since. I cannot claim to be familiar with all that has been written, nor even to understand all that I have read about them, but I think I am justified in saying that meteorologists are even now not clear as to whether the circulation of air, which is such a conspicuous feature of the revolving storm as shown on our maps, is the primary element of the problem, the *fons et origo malorum*, or is merely the exaggerated by-product of more general atmospheric currents, possibly in

the upper regions, just as the eddy, or even the whirlpool, is the by-product of the flowing stream and its boundaries.

Mr. John Aitken has described experimental illustrations of the formation and motion of revolving columns of air by blowing past an obstacle, and the exaggeration of rotational energy by centripetal action.[1]

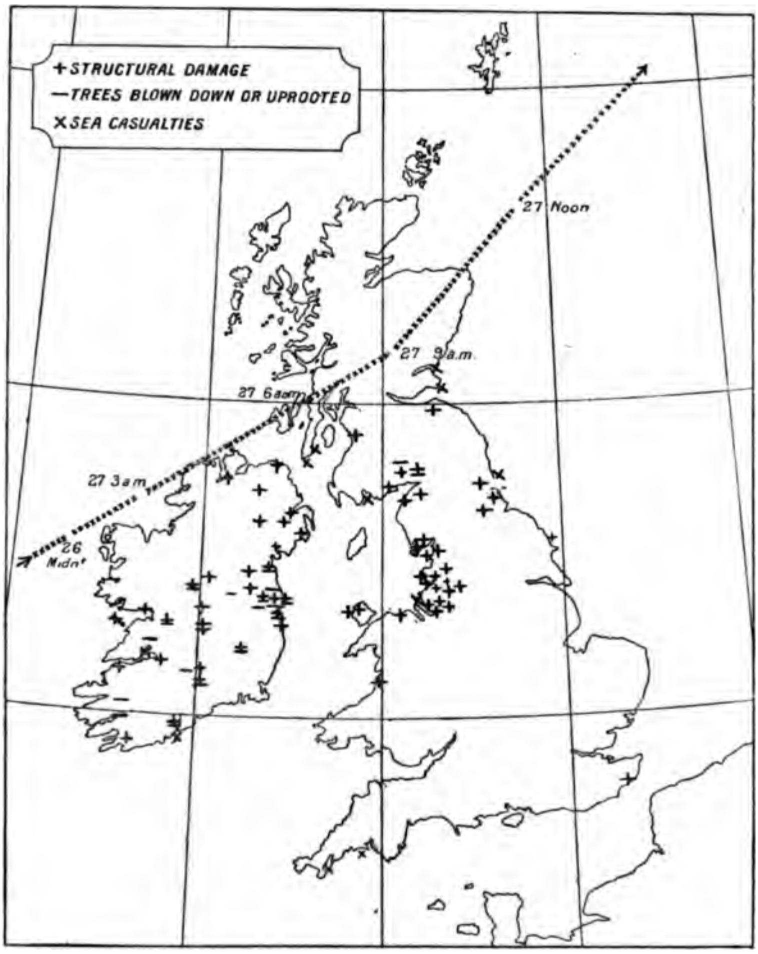

FIG. 1.—Damage occasioned by Storm.

He has given a rule for referring the direction of motion of the revolving storm to that of the dominant wind, and has given reasons for regarding the circular form of the storm as being the last stage in the life-history of the phenomenon. These ideas seem to favour the second of the two alternatives mentioned above; and if that view be correct, meteorologists who want to understand the ultimate causes of the destruction ought not to fix their attention too closely on the circulation, but search for the

[1] *Transactions of the Royal Society of Edinburgh*, vol. xl. part i. p. 131.

dominant current which gives rise to it, and the centripetal action which intensifies it.

I fear that those who watch a weather map day by day, and who are, of all people, most interested in the application of rules which will indicate the path and the future history of an approaching depression, would find it difficult to recognise the universal application of any rule, whether of direction or speed of motion of a storm centre, though they could find some effective instances of many rules. Whether from lack of information or from some inherent uncertainty about the constitution of a wind circulation, a practical meteorologist is still liable to misunderstand the behaviour and prospects of a travelling depression.

With some hesitation I should like to suggest that we are not yet by any means certain as to what does travel. What is represented as travelling on the maps is an arrangement of isobaric lines which is found on one day in one position, and is supposed to be identical, in a sort of way, with another more or less similar distribution found elsewhere on another day. Presumably, what is meant when a disturbance is said to have travelled from one position to the other, is that a certain sequence of weather changes has passed successively over the intermediate points on the map, and their neighbourhood, during the intervening twenty-four hours, and that the distribution of weather in the region of the final position of the centre is, *mutatis mutandis* (*i.e.* making allowance for changes in its character or intensity during the interval), the same as the distribution was twenty-four hours earlier in the region of the initial position In many cases such a statement is palpably true, and weather conditions travel with the characteristic barometric distribution; but the changes that must be permitted under the proviso "*mutatis mutandis*" are so liberal that we soon approach circumstances under which travel ceases to have any real meaning. When the word "travel" is applied in other connections it is associated with certain definite characteristics. When matter travels, we recognise it in the last resort by its chemical composition; when a vortex ring travels, it carries recognisable matter with it; when a wave travels, its period of vibration is its recognisable feature, and it has a definite velocity under definite conditions; but when a meteorological disturbance travels, any change may be allowed under the provision "*mutatis mutandis.*" We make no condition as to actual shape or intensity of the disturbance; we assign no limit to its freedom as regards its direction of motion or the rate at which it travels. For as long as possible we avoid the suggestion that a disturbance has originated, or simply subsided, within our area, though both these contingencies are not by any means unknown in practice. The only inexorable condition that I know of is that the velocity of the depression for the interval between successive observations must be small enough to bring the day's path within the linear dimensions of the map, otherwise the depression might be regarded as having moved to the position occupied next day, not by itself, but by its successor. I do not wish to undervalue in the least the enormous services which have been rendered in practical meteorology by the introduction of the conception of the travelling depression and the attention bestowed upon it; I fully recognise that, whatever form it takes, it still remains the subject of our most careful attention and solicitude. It is therefore from no want of respect, but solely with the

object of pressing a plea for investigation of the actual phenomena from a slightly different point of view, that I say that more complete knowledge of the natural history of depressions may show that we are liable to push the idea of a travelling depression too far. We may overstrain our knowledge in the endeavour to regard every depression found on the map as an individual that must have come from somewhere and must be going somewhere. We call them all "storms," whatever their intensity, and mark their tracks; but I doubt whether we know enough about them to connect in any real physical sense the local development of destructive energy in the neighbourhood of the British Isles with a circulation, perhaps of light airs, originally identified near the eastern coasts of the United States and supposed to travel at the rate of some thousand miles a day to these Islands.

It is, I think, too probable that by assuming the historical identity of these phenomena in our present state of knowledge, we tend to obscure rather than to elucidate the difficult problems associated with the origin and laws of storms. For my own part, I have made attempts at different times to derive some recognisable laws of transmission of disturbances from the series of very complete charts for 13 months of 1882-83 issued by the Meteorological Council. I must confess that in trying to trace depressions over a very large area I have been irresistibly reminded of the colloquy in *Hamlet* between Horatio and his officers, who were prepared to use strong measures to extort its secret from the ghost.

Mar. Shall I strike at it with my partizan?
Hor. Do, if it will not stand.
Ber. 'Tis here!
Hor. 'Tis here!
Mar. 'Tis gone!

I cannot help thinking that we are apt to mistake the barometric similitude for a substantive reality, and that what is credited as travelling across the Atlantic as a storm is sometimes not much more substantial than the apparition which would not speak, even under the influence of so effective a weapon as the partizan.

Nor is it difficult to imagine conditions under which a will-o'-the-wisp flicker of the position of the barometric minimum might occur, although the word "travel" would be hardly appropriate. Imagine a distribution of isobars, as represented in Fig. 2 (p. 238), with winds along them in opposite directions. The 29·7 isobar represents an imaginary line of minimum pressure, with oppositely directed currents of air on the two sides. Such a distribution in its complete form is, so far as I know, never found on a map, and is never likely to be found, for it represents an essentially unstable condition of motion. It would be disturbed, and probably thrown into local circulation, by differences of temperature of adjacent layers of air, or of air and sea. The conditions which would tend to produce it may certainly exist; but the line of uniform minimum would break up into local minima, and the position of a local minimum would depend upon local circumstances. The existence of a minimum at any point would not be conditional upon the previous existence of a minimum in some other locality travelling along the line. In fact, the origin and development of a storm circulation would depend upon the local conditions, and not upon the previous existence of a storm circulation else-

where, although the development in one locality might annihilate or overpower the causes of development in another locality and produce a displacement, and thus a *quasi*-travel of the minimum. The apparent speed of travel would, however, depend simply upon the distance of the new and overpowering centre of disturbance, and not upon any general properties of disturbances, as in the case of wave motion.

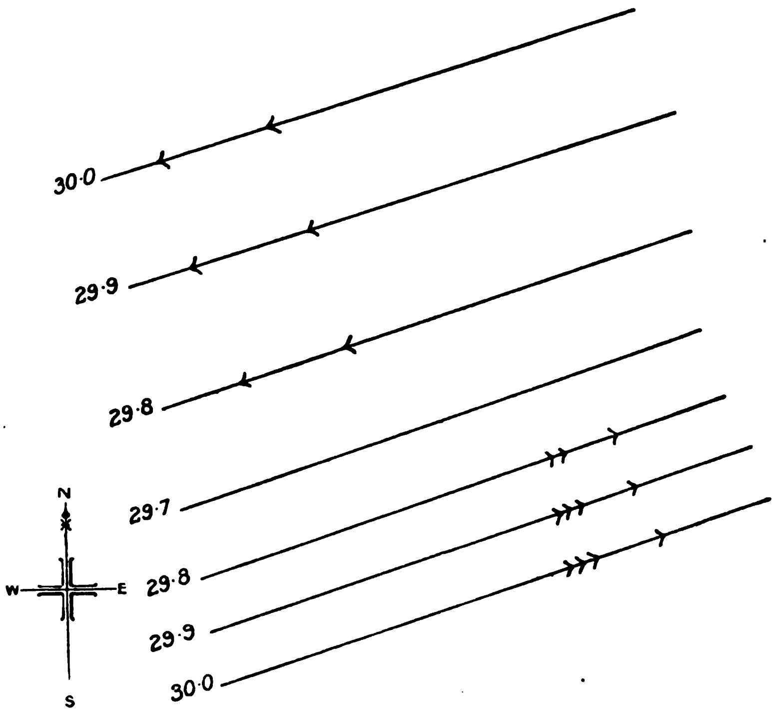

Fig. 2.—Imaginary Isobars.

The difference between the real velocity of motion of the travelling storm and what I will call the fictitious velocity of displacement of a centre of activity may be a difficult one to define, and the transition between the two may even be almost insensible. I should like to suggest an illustration of this point. A travelling steamer sends out two waves, one on either side; the line of the wave on each side makes a definite angle with the steamer wake, depending upon the relative magnitudes of the velocity of the steamer and the natural velocity of progression of the waves. Here we certainly have a progressive reality, the steamer, sending out wave disturbances on each side. Now suppose that instead of the waves going out from the steamer's wake their motion is exactly reversed, and the waves, approaching each other obliquely, meet on the line of the wake. As the wave lines are inclined to each other, the waves will meet and combine to produce double disturbance at successive points along the wake, and now not a real steamer but a real and conspicuous disturbance will visibly travel along the water, marking

out an exact reversal of the original motion of the steamer. Next, instead of merely reversing and sending back a uniform wave from each side, let waves of quite irregular magnitudes, originated independently, be sent at irregular times towards the different points of the steamer's wake. Various points on the wake will become the seat of conspicuous disturbances, but under these circumstances to regard a disturbance appearing at one point as having travelled along the wake would be inappropriate, and yet the transition between the conditions for the appropriate and the inappropriate use of the word could be made by nearly insensible stages. Although it may be hard to draw a definite line of demarcation between the cases, it may be apposite to remark, in considering the three types included in the illustration—(1) the waves passing outward from the wake, (2) the reversed uniform waves proceeding towards the wake, and (3) the irregular waves proceeding towards the wake—that in the first type the travelling steamer is the most important consideration, in the second the opposing waves, and the resultant disturbance in somewhat less degree, while in the third the whole importance lies in the opposing waves.

I do not wish to offer at this stage any ready means of differentiating between the progress of a real travelling storm—meaning thereby a barometric minimum associated with regular sequence of weather conditions—and a displacement of barometric minimum which cannot appropriately be said to have travelled. I think I may safely say that none of the real travelling depressions which I have examined with any care have travelled faster than the highest velocity of the wind in the circulation, and it is from that starting-point that I should proceed towards the examination of the question. It seems to turn upon determining whether the wind originally causes the eddy, or the eddy the wind; and we come back therefore to the consideration of the question whether the vortex eddy or, for the matter of that, the V-shaped "circulation" be a primary or only a secondary effect.[1] One means of contributing towards the solution of this crucial question is to examine with greater precision than has hitherto been done what actually takes place as regards the motion of the centre and the motion of the component air streams in various examples of atmospheric depressions. I propose to do this for the case of the unmistakable travelling storm of February 26-27, 1903. The multiplication of observations in this country, and especially the extended use of self-recording instruments, renders this possible at the present time.

There may be some misapprehension as to what motion of air may be expected to take place in a travelling storm of normal and permanent type. I will therefore devote a few lines to the consideration of that question. The accepted representation of the instantaneous motion of air

[1] *Note* (June 20, 1903).—With reference to a remark by Mr. Dines in the discussion following this paper, it may be as well to explain that, in speaking of the eddy as a secondary effect, I had no wish to overlook the influence of local convection in modifying the phenomena and probably increasing the intensity of the circulation. The question proposed may perhaps be more clearly put in the following form: Whether there are any recognisable dynamical or thermal conditions outside the area immediately affected by the revolving strom which are necessary for the development or persistence of the storm, or whether local convection within the storm area itself or its immediate path must be regarded as the only physical agency necessary for the phenomena?

in the neighbourhood of a low-pressure centre is a combination of rotation and radial motion represented by spirals with a certain incurvature, which conveys the idea that the air approaches the centre by essentially similar paths from all sides. This suggestion appears to me to be apt to lead to very serious misapprehension. The apparent spiral motion is a merely instantaneous representation of the state of motion of a number of bodies. The actual motion of the air in a travelling storm is not a symmetrical spiral motion of air masses towards a centre, but a complicated kind of dance figure, in which the dancers group themselves at any instant in such a way that they can be sorted into spirals; but the path of any individual dancer may, and generally does, make no real approach to the spiral form. The spiral motion only becomes complete if the storm centre becomes stationary, and the conventional diagram represents the true paths in that case; but when the incurvature is small and the velocity of travel great, the general resemblance to symmetrical spiral motion is lost. To simplify the preliminary consideration of the question on this occasion, I propose to neglect the incurvature and regard the instantaneous motion of the travelling storm as purely rotational. I wish to consider the actual motion of the component air under the circumstances indicated—in other words, the actual geographical path of a balloon floating in the air within the influence of the cyclonic disturbance. For ease of distinction I shall call the actual path of the air a "trajectory," reserving the use of the word path for the motion of the storm centre. If the centre of the storm were stationary the balloon would be carried round in a circle, but if the storm centre moves the trajectory is not a circle but something entirely different.

I suppose, further, as a special case, that the velocity of the wind is uniform over the area covered by the circular storm, and that the velocity of travel of the storm centre happens to be the same as the velocity of the wind. The trajectories will be of different shape according to the original positions of the points under consideration with regard to the centre and its path. A point in front of the approaching centre will start at right angles to the path, but will be overtaken by the advancing storm and have its direction of motion reversed before it has made a half circle, and in the rear of the storm it will find itself in the region of nearly parallel isobars and travel away from the line of the path. Its trajectory will be a curious hook-shaped curve. A point behind the centre will get into the region of the isobars approaching more and more nearly to parallel straight lines inclined to the direction of motion of the storm. Its trajectory will not differ much from a straight line inclined to the path. A point in the transverse line through the centre on the left of the path will gradually approach and cross the path in the rear and come into the concluding condition of the previous cases, while a corresponding point on the right of the centre will not have its direction of motion affected but will travel along always keeping the storm centre on its left. Its trajectory will be a straight line parallel to the path. No point moves in a circle or in anything approaching to it. The apparent simplicity of motion as represented on an isobaric map becomes therefore very misleading when we deal with the actual motion of air. The trajectories in any real case depend upon the velocity of the centre and the incurvature as well as the original position of the points, and hence

they are a series of exceedingly complicated lines always combining to show a comparatively simple and symmetrical arrangement of velocities at any instant.

For any particular case, assuming a certain distribution of winds and a velocity of travel, it is easy to construct a diagram showing the trajectories for a series of particles which at any particular instant take their places on a circular isobar. Such trajectories are of course, to a certain extent, hypothetical, but at least they approximate to the motion of air in a real cyclonic depression. We may distinguish two extreme types—first, Type A, the stationary storm with symmetrical incurvature, drawing its air equally from all sides; and secondly, Type B, the storm made up of winds of uniform velocity but varying direction which travels with the same velocity as one of its component winds. I have constructed the trajectories for this hypothetical case, and find them to be looped curves, as shown in the figure (Fig. 3), for all points, with the

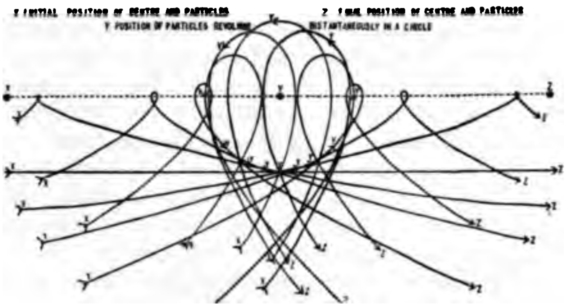

FIG. 3.—Ideal Trajectories.

exception of those carried with the wind which blows in the direction of the moving storm. For these the trajectories are straight lines. A consideration of these trajectories leads at once to the conclusion that a travelling storm of this type takes all its air from one side only, and throws as much out on the same side but in a different direction. A storm of this kind, travelling, let us suppose, from west to east, although at any instant it is composed of winds blowing from all points of the compass, can thus be resolved into a general drift of air towards the path of the storm *in front of the centre*, from directions between West and South, and a general drift leaving the path of the storm from *behind the centre*, and blowing from between West and North, together with a wind that has the same direction as the path and travels along with the storm. The winds from other directions, although equally strong while they last, are comparatively transient. The Southerly to Westerly winds entering the storm are shown in the figure by the trajectories X, X, and the Northerly to Westerly winds leaving it by the other extremities of the same trajectories, lettered Z, Z. The wind which goes along parallel with the storm is easily recognised. The extremities of the trajectories indicated by the letters X show the starting-points or simultaneous positions of a series of particles which will take their places on a circle marked Y, indicated in the middle of the figure. At the time

of starting the storm centre is also marked X. When the particles have formed a circle the position of the centre is marked Y, and when the storm centre has reached Z the set of particles will have travelled to the points also marked Z.[1]

In this way particles flow in to form circles represented by the isobars of the storm in consecutive positions, and flow out again when the centre has passed.

The most salient characteristics of the two types are, of A, the storm draws its air symmetrically from all sides, and none is thrown out; and of B, the storm draws its air from one quadrant only, and throws out as much in the other quadrant on the same side of the path.

In both there is doubtless vertical motion. In the first an upward vertical motion is all that is required; in the second there must be vertical motion downward to supply any air removed by upward vertical motion, so that in a storm of Type B there must be as much downward convection within the storm area as upward convection. Upward convection should be productive of cloud and rain; downward convection of cold air at the surface, because convection implies the replacing of warm air by cold. These are possible signs of distinction between the types.

Between these two types there must be many storms of an intermediate Type C, in which there is motion of the storm centre, but less rapid than in Type B, associated with more or less incurvature.

It must be remembered that storms of all these types would be represented by the same distribution of isobars, and, apart from the difference as regards incurvature, by the same distribution of winds in a map representing the condition at any one instant. The isobars are in each case supposed to be concentric circles, and the air circulates round them with the appropriate incurvature, if there is any. The difference between the types is only apparent when successive maps are compared, and the air trajectories are drawn from the travel of the air in the intervals.

I do not know of any attempts yet published to trace the actual paths of air in a travelling storm. It is only possible when a considerable number of curves from self-recording instruments can be obtained. It is even then an uncertain enterprise, owing to the difficulty of determining the wind velocities and directions with accuracy; but I think it is of sufficient importance to be undertaken, and the approximation to reality is close enough to give valuable information of at least a general character. Mr. Lempfert has already drawn for me the trajectories of a storm of intermediate type—a slow-moving storm with pronounced incurvature—which passed over Scilly in January 1901.[2] With his assistance, I hope to carry out an investigation of these questions, and to approach them not only by determining the approximate trajectories of air in actual storms, but by constructing them for storms of certain ideal types approximating as nearly as possible to actual atmospheric conditions.

In the present investigation, apart from what has been mentioned, I

[1] The curves in the figure may be represented by their cartesian equation $(a-y)(2a+y)^2 = 9ax^2$ where the axes are the path of the centre and the line of symmetry of a loop respectively. They are all similar in shape, but differ in size according to the magnitude of a, the ordinate to the top of the loop. The straight line parallel to the path represents the limiting case when $a=0$.

[2] A diagram of the trajectories of this storm, which travelled northward at the rate of about 10 miles per hour on January 8-10, 1901, was exhibited at the Meeting.

have limited the application of these ideas to the tracing of the trajectories of the air that appeared as violent gales in various phases of the storm.

The line of investigation taken in this paper will now, I hope, be clear. In the first place, to obtain more effective representation of the atmospheric processes, Mr. Brodie has compiled weather maps for every third hour of the period under consideration, from all the observations and records available in the Meteorological Office, and others which have been kindly lent for the purpose; and, in the second place, Mr. Lempfert has compiled from the maps the actual trajectories or geographical paths of air which appeared as destructive gales in certain parts of the storm as shown in the Weather Maps. With the view of supplying material for tracing the physical phenomena associated with the different phases of the storm, Mr. Brodie has prepared a diagram from the automatic records at various places similar in form to one which he prepared at my suggestion for the *Report of the Meteorological Council* for 1901 to represent changes associated with a memorable thunderstorm.

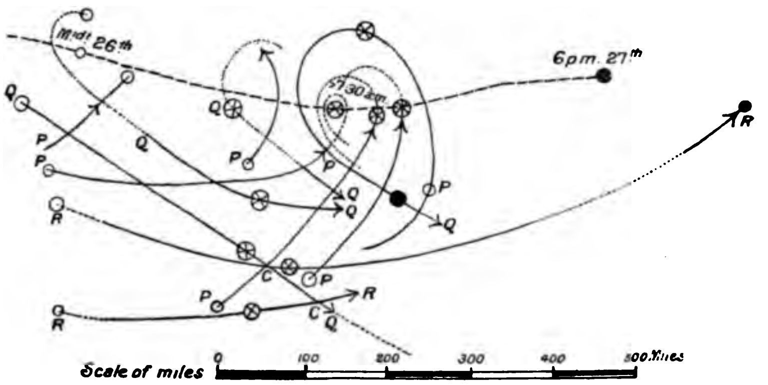

FIG. 4.—Trajectories of Air in the Storm of February 26-27, 1903, derived from Records of Wind. Those parts which are added by extrapolation from isobaric distribution are dotted.

— — — — — — Path of Centre.
P Trajectories of air passing to the front of the centre.
Q ,, ,, leaving the rear of the storm.
R ,, ,, approximately parallel to the path of the centre.
C Points of convergence and divergence on the trajectories parallel to the path.
Simultaneous positions marked thus :—○ Midnight, Feb. 26th.
⊗ 7.30 A.M., Feb. 27th.
● 6 P.M., Feb. 27th.

One of the most interesting, and perhaps the most important, of the conclusions is that the trajectories are of such a character as to show that the storm of February 26-27 must be classed as belonging to the Type B, which has been described above at some length.

As evidence for this statement I will refer to Fig. 4, which shows the relation of the trajectories constructed from the recorded directions and velocities of the wind (Figs. 10 and 11) to the motion of the centre. On comparing the lines of this diagram with those of the ideal diagram for a storm of Type B (Fig. 3), and considering the shapes of the curves, the resemblance between the corresponding portions of the curves of the two diagrams is unmistakable. Reference is made here only to the full

lines in the diagram, Fig. 4. The dotted portions are continuations drawn not from the recorded velocities of winds but from the shapes of the isobars. The distribution of winds associated with such isobars leaves no alternative form for the continuation of the trajectories; but the evidence for those portions of the curves is less direct than that for the full lines. The material is not perfectly complete, but so far as it extends the characteristics of the ideal curves are reproduced with a fidelity quite unusual in the application of theoretical reasoning to weather changes. It is to the shapes of the curves that attention should be directed, and not to their actual position on the map. If the storm travels practically unchanged there will be corresponding trajectories for each position of the centre. The following may be enumerated as the characteristics common to the two diagrams.

1. The more central area of the storm circulation is fed from outside by winds passing to a region in front of the centre, with directions in the quadrant between the direction from which the storm comes and the direction at right angles thereto on the left facing the coming storm.

2. When the storm centre has passed, corresponding winds blow out from behind the centre with directions from the adjacent quadrant on the other side of the path.

3. The winds from the remaining quarters will be comparatively transient in any locality, as the changes in them take place with great rapidity. These winds are represented by the parts of the loops of the curves above the path of the centre.

4. No air is taken into the storm area from the "Northern" side of the path.

5. There is a great convergence of winds behind the centre to points in the line of the "trough." This convergence is associated with corresponding divergence in front of the trough, and apparent crossing of the trajectories at the trough itself.

The convergence and divergence must have reference to upward and downward convection; but before going further into the consideration of the results of the investigation, I propose to give a representation of the recorded phenomena of the storm.

Observations and Records.

I desire to record my thanks for assistance from the observers who have contributed observations and lent records for use in this inquiry.

Many of the barograms from Ireland were obtained through the instrumentality of Prof. C. J. Joly, Astronomer Royal for Ireland, who had collected a very large number of records, of which a short discussion appeared in *Symons's Meteorological Magazine*, vol. xxxviii. p. 49, and who kindly supplied the addresses of the owners of aneroidographs in selected positions.

The following is a list of the observations and records contributed to the Meteorological Office, or specially lent for the purpose and utilised in the composition of the maps and other meteorological information with regard to the storm.

LIST OF STATIONS FROM WHICH INFORMATION WAS OBTAINED FOR THE PREPARATION OF THREE-HOURLY CHARTS.

1. Stations supplying Continuous Records of Pressure, Temperature, Wind, and Rainfall.

Station.	Authority.
Aberdeen	The Meteorological Council.
Glasgow	Prof. L. Becker, Ph.D.
Stonyhurst	Rev. W. Sidgreaves, S.J.
[1] Southport	J. Baxendell, for the Corporation.
Falmouth	The Meteorological Council.
[1] Berkhamsted	E. Mawley, F.R.H.S.
Oxford	A. A. Rambaut, M.A., F.R.S.
Kew	The Meteorological Council.
Valencia	,, ,,

[1] Record supplied by the Royal Meteorological Society.

2. Other Stations supplying Continuous Records.

Station.	Information Supplied.	Authority.
Fort William	Pressure, Temperature, and Rainfall	The Meteorological Council.
Rousdon	Pressure, Wind, and Rainfall	Hon. Lady Peek.
Armagh Observatory	Wind and Rainfall	The Meteorological Council.
Scilly	Pressure and Wind	,, ,,
Yarmouth	,, ,,	,, ,,
Deerness (Orkney Islands)	Wind	,, ,,
North Shields	,,	,, ,,
Holyhead	,,	,, ,,
Alnwick Castle	,,	R. Kyle, for the Duke of Northumberland.
Cronkbourne (Isle of Man)	Pressure	A. W. Moore, M.A., C.V.O.
Sumburgh Head	,,	The Meteorological Council.
Malin Head	,,	,, ,,
Newton Reigny (Penrith)	,,	T. G. Benn.
Westminster	,,	The Meteorological Council.
Forgandenny	,,	C. L. Wood.
Penbedw	,,	H. W. Buddicom.
[1] Cheadle	,,	J. C. Philips.
[1] Worksop	,,	H. Mellish, J.P.
[1] Haverfordwest	,,	E. P. Phillips, F.R.C.S.
Belfast	,,	Messrs. F. M. Moore, Ltd.
[1] Ardgillan	,,	Capt. E. R. Taylor.
Belmullet	,,	Lieut. F. H. Goldfinch, R.N.
Ballynakill	,,	G. H. F. Beamish.
Newton (Sligo)	,,	J. Crampton Lees.
Streete (Westmeath)	,,	W. E. Wilson, F.R.S.
Roslevan (Ennis)	,,	Miss A. L. Scott.
Berehaven	,,	O. P. Hodgson, R.N.
Skibbereen	,,	W. Ricketts, R.N.
Queenstown	,,	The Royal Cork Yacht Club.
Wexford	,,	J. W. Griffith.
Kilkenny	,,	H. Carlton, for the Marquis of Ormonde.

[1] Record supplied by the Royal Meteorological Society.

3. Stations supplying Observations for 9 a.m. and 9 p.m.

Station.	Authority.
Lairg	Rev. D. Macrae.
Strathpeffer Spa	R. Fortescue Fox, M.D.
[1] Gordon Castle	C. Webster, for the Duke of Richmond and Gordon.
[1] Dundee	J. Carnochan.
[1] Edinburgh	A. Buchan, LL.D., F.R.S.
Glencarron	D. D. Munro.
Laudale	A. Fletcher, for T. G. H. Newton, M.A.
[1] Poltalloch	D. S. Melville, for Lord Malcolm.
Cally (Gatehouse)	W. Thomson, for G. H. Murray Stewart.
Morpeth (Cockle Park)	J. H. J. Farquhar, for the Northumberland County Council.
Seaham	G. H. Aird.
[2] Scarborough	W. W. Larkin, for the Corporation.
York	H. M. Platnauer, B.Sc.
Belvoir Castle	W. H. Divers, for the Duke of Rutland.
[2] Lowestoft	C. W. Edwards, for the Corporation.
Cambridge	Miss A. Walker, for Sir Robert Ball, F.R.S.
Chatham	The Instructor in Surveying.
Aspatria	J. Smith Hill, B.Sc.
[2] Llandudno	W. Little, for the Town Council.
Edgbaston	A. Cresswell, for the Midland Institute.
[2] Buxton	W. Pilkington.
Woolacombe	B. Fanshawe.
Haverfordwest	J. W. Phillips.
Plymouth	H. Victor Prigg, C.E., for the Corporation.
Southampton	A. Vaughan, for Director General of Ordnance Survey.
[2] Guernsey	A. Collinette.
Eastbourne	R. Sheward, for the Corporation.
Belfast (Queen's College)	J. Wylie.
Markree Castle (Co. Sligo)	J. Armstrong.
Dublin City	Sir J. W. Moore, M.D.

[1] Return supplied by the Scottish Meteorological Society.
[2] Return supplied by the Royal Meteorological Society.

4. Stations supplying Observations for 8 a.m. and 6 p.m.

The Telegraphic Reporting Stations of the Meteorological Council, with Bidston Observatory (W. E. Plummer), Newton Reigny (T. G. Benn), and Bath (W. H. Symons, M.D., for the Corporation).

Note on Self-Recording Instruments.

The endeavour to utilise the curves from many independent barographs for the construction of synoptic charts brings into prominence the necessity for some organised means of checking the time and scale values of these instruments. Prof. Joly has already called attention to this point, and it is no exaggeration to say that the want of some such system adds very greatly to the labour of correlating the observations and also to the uncertainty of the results. The unavoidable divergences of the aneroid from the mercury standards are complicated by errors in the ruling of the paper, the setting of the paper on the drum, the adjustment of the pen and the going of the clock. These instruments are now in such general use that without any serious addition to the expense, arrange-

ments could be made for avoiding many of the incidental errors. The detailed ruling of the paper to two hours and 20ths of an inch is probably unnecessary, and a base line ruled automatically by an auxiliary pen would be of great advantage. At Cooper's Hill, Prof. Macleod used to regulate the time scale by a time mark at an exact hour each day, at 10 o'clock or 12 o'clock as the case might be, made by tapping the instrument. That information with a corresponding reading of a standard barometer by which to set the barometer scale would add very largely to the scientific usefulness of these instruments. The time of starting a new sheet and of removing it and the barometer readings at these times are sometimes given, but the readings of the trace at precisely these times are often the most ill-defined readings of the whole week owing to the back-lash and unintentional markings. It is much better to make the reference marks while the instrument is running.

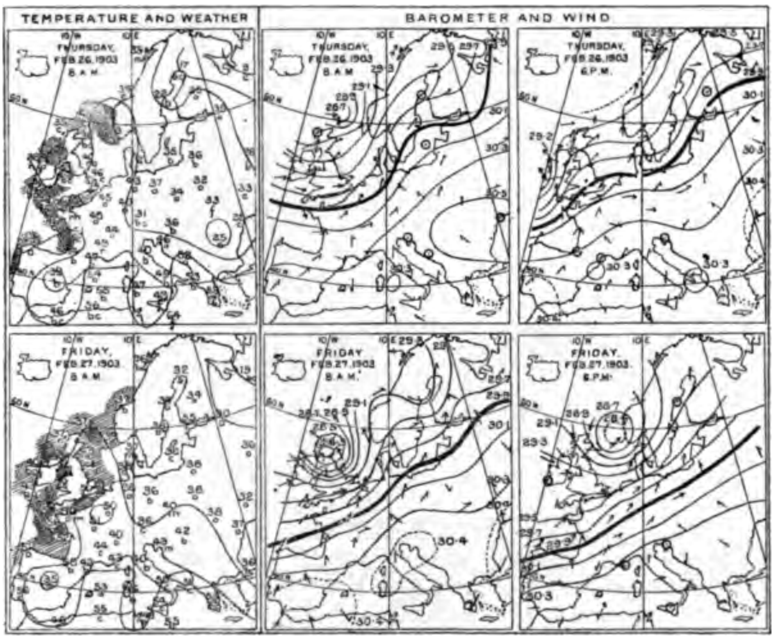

FIG. 5.—Maps from the *Weekly Weather Report.*

Representation of the Data.

From the information brought together the following have been compiled:—

The Charts and Notes for 8 a.m. and 6 p.m. of February 26 and 27, which are published in the *Weekly Weather Report.* Reproduced in Fig. 5.

Synoptic Charts for the North Atlantic for 8 a.m. on February 25 and 26, published in the *Pilot Chart* for May 1903, also a chart showing the track of the depression across the ocean.

Isobaric Charts for every third hour from 9 a.m. on the 26th to 9 a.m. on the 28th. Twelve of these are reproduced in Figs. 6-17.

Two Charts of the distribution of rainfall during the passage of the storm as registered at 8 or 9 a.m. on the 27th and 28th respectively. Reproduced in Figs. 18 and 19.

Charts of the trajectories of air which produced certain winds of gale force at the several stations derived from the synoptic charts and from measurement of the wind velocities. Reproduced in Figs. 20 and 21.

A Diagram of the results given by self-recording instruments at various observatories, showing the variations of pressure, temperature, and rainfall, and the changes of the wind during the passage of the storm. Reproduced in Fig. 22.

Fig. 6.

Fig. 7.

A point suggested by a letter in *Nature*[1] from Lord Rosse concerning the possible explanation of the remarkable effects of the wind in uprooting trees, by periodicity in the wind force, cannot be adequately dealt with by the data available. The time scale of the anemograph records is too much contracted for the record to indicate such fluctuations as would be synchronous with oscillations of trees.

Notes on the Maps and Diagrams, Figs. 5 *to* 22.

The general features of the distribution of pressure over Europe during February 26 and 27 are shown on the maps, which are taken from the *Weekly Weather Report* (Fig. 5).

At 8 a.m. on the 26th a well-defined anticyclone lay over South-eastern Europe, and a cyclonic disturbance was to be found in the north-west with its centre between the Orkney Islands and the Norwegian coast, so that the general trend of the isobars was north-easterly. The wind was accordingly from the West or South-west, but a well-marked Southerly current prevailed over Scandinavia. This Southerly current

[1] *Nature*, vol. 67, p. 462.

in front of the depression forms a very characteristic feature both of this depression and of that which caused the gales on the following day. It can be identified on all the maps.

FIG. 8.

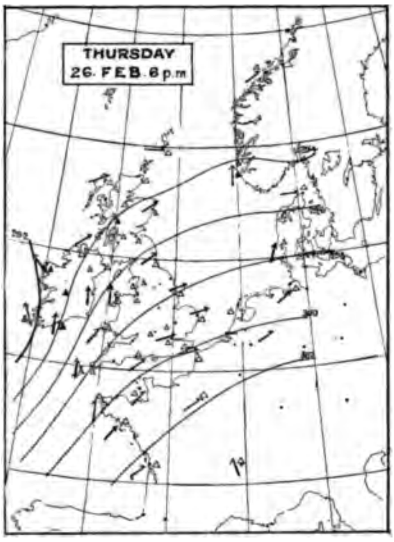

FIG. .

FIG. 10.

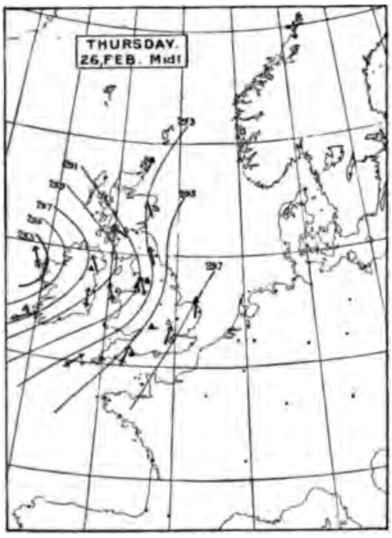

FIG. 11.

The maps for 9 a.m. and noon show a continuation of the strong Westerly or South-westerly winds noticed above. During the afternoon the wind backed to the Southward, and at 6 p.m. the isobars over Ireland and the west of England had assumed a southerly direction with a slight concavity towards the west, indicating the near approach of the

new disturbance. Attention has already been called to the gale from the South, or from some point somewhat to the East of South in the case of stations near the path which formed the commencement of the storm. As the disturbance advanced, the wind veered to the South-west and finally to the West.

At 9 p.m. a fierce Southerly gale was blowing over Ireland and the west of England. Shortly after 9 p.m. the wind commenced to back at Valencia, and at midnight, when the storm centre lay somewhere west of Blacksod Point, we find the gale from the South affecting the greater part of England and a South-westerly gale blowing in the south-west, while at Valencia the wind had already veered to the West. The maximum velocity of 63 miles in an hour at this station was experienced about this time. As the storm centre moved in a northerly direction with a velocity

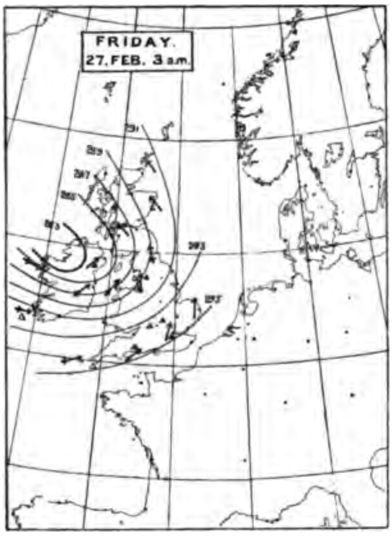

Fig. 12.

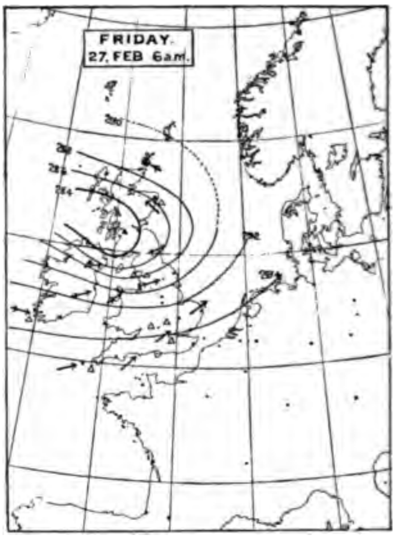

Fig. 13.

of about 30 miles an hour, the South-westerly gale advanced to other parts of the country. It blew with great violence during the night in the neighbourhood of Dublin and over the Irish Sea; 66 miles in the hour were registered at Kingstown from 4 to 5 a.m.

In the rear of the South-westerly gale there followed a gale from the Westward which attained its greatest intensity over Lancashire between 6 a.m. and 9 a.m. on the 27th. An average velocity of 65 miles per hour was recorded at Southport for 7 a.m. As the depression passed away over the North Sea towards Norway it was succeeded by a secondary which took a rather more southerly course than the main depression. Its approach is first indicated on the maps by the backing of the wind at Scilly and Falmouth at noon on the 27th.

The particulars of direction and force of the wind are sufficiently represented on the maps without further description. The distribution of rainfall for the epoch of each map is represented so far as it is known by triangles inserted in the map for each station for which information

as to rainfall is available. For those stations where rain was falling at the hour of the map, the triangle is filled up in black; for those where rain was not falling it is left blank. The distribution of rainfall for two

FIG. 14.

FIG. 15.

FIG. 16.

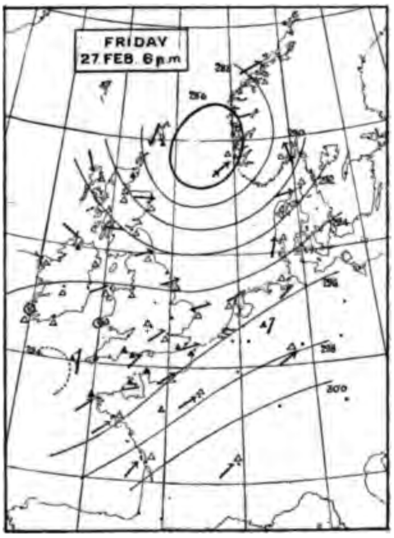

FIG. 17.

24-hour intervals, viz. those ending at 8 a.m. or 9 a.m. on the 27th and 28th respectively, is represented in Fig. 18 and 19. The position of the storm centre when the division is made between the two measured falls, viz. from 8 a.m. to 9 a.m. on the 27th, was between Fort William

and Dundee. The heaviest rainfall, 1·0 inch or more, was therefore behind the storm centre.

The Trajectories of Air.

It should be noticed in passing that so far as observations go, the gale was confined to the southern side of the depression; the winds on its north and west sides do not attain a greater wind velocity than that which is represented by force 6 on the Beaufort Scale. In the diagrams (Figs. 20 and 21) the trajectories of the air which took part in these various gales are represented. A number of conspicuous wind observations of gale force were selected, and the probable path of the air in them was, wherever possible, traced both backwards and forwards. The starting points have been indicated by means of arrowheads, and the hours

FIG. 18.—Rainfall.

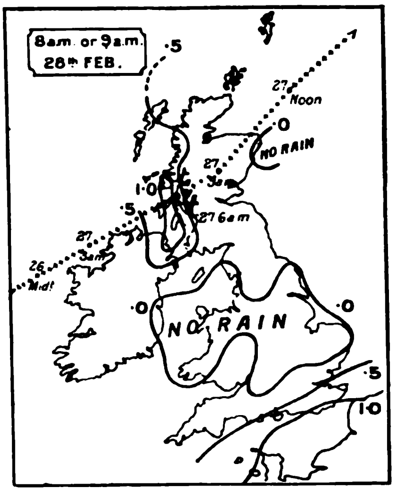

FIG. 19.—Rainfall.

corresponding to them are those underlined in the diagrams. Each of the three-hourly maps has been used to draw the path of the air during the $1\frac{1}{2}$ hours previous and subsequent to the hour for which the map represents the distribution of pressure. The direction and length of each step has been estimated from the observations of the direction and velocity of the wind made at neighbouring stations.

A, B, C (Fig. 20) represent the trajectories of the Southerly gales which blew over Stonyhurst at 3 a.m. on the 27th, over Ballynakill at midnight, and over Pembroke at 9 p.m. on the 26th respectively. The points in which A and B meet the path of the storm are very near the position of the centre of the disturbance at the time when this intersection took place. These trajectories end near the centre of the storm; if continued, the direction of motion of the air would be rapidly reversed by the circulation round the passing centre, and loops would be formed similar to but smaller than that of the trajectory E described below. C, on the other hand, crossed the path at a point some distance in front of

the storm centre; but lack of observations makes it impossible to trace its subsequent course.

D and E are the trajectories of the Southerly and South-easterly gales experienced at 3 a.m. at Shields and Aberdeen respectively. When traced backwards both are found to have originally had a Westerly direction, showing that the air in them took part in the Westerly circulation shown on the map for 9 a.m. on the 26th, and was subsequently drawn northward as the Southerly gale advanced. When traced forward, these trajectories suffer different fates. D approaches very near the centre of the disturbance at about the same time as A (7.30 a.m.). E forms a loop round the centre, and ultimately appears as the Westerly wind which formed the final phase of the storm. C, if continued, would

FIG. 20.—Trajectories.

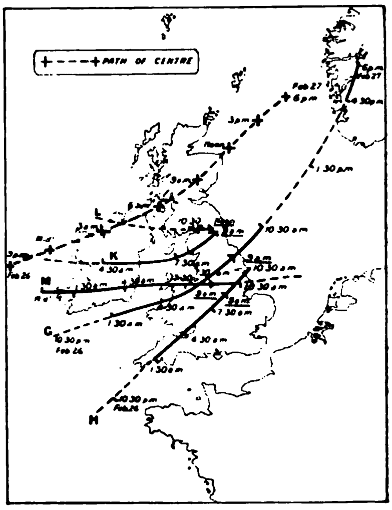

FIG. 21.—Trajectories.

probably trace out a similar course. F (Fig. 20), G and H (Fig. 21) are trajectories of South-westerly gales. Of these, F, if continued farther, would reach the path of the depression concurrently with A and D. G, on the other hand, does not approach the centre rapidly, but remains at an almost constant distance from the path of the storm; if continued in the same direction across the North Sea (broken line) it reaches the Norwegian coast just at the right time to take part in the South-westerly gale shown at Skudesnaes on the map for 6 p.m. on the 27th. By this time the wind was Southerly over Sweden and the Baltic. H and K would probably take a similar course.

Finally, L and M are trajectories of the Westerly gale which followed in the rear of the depression. The Westerly wind blowing at Buxton at 9 a.m. on the 27th was taken as the starting point for M; when traced backwards, this trajectory shows us that the air of the gale which blew over Buxton at 9 a.m. on the 27th took part in the Westerly gale which raged near Valencia at midnight. Continued forwards it would apparently cross the North Sea in a Westerly direction.

A striking feature of these curves also is the way in which they

approach and even cross one another. This feature is fully represented in the curves for the ideal trajectories (Fig. 3). For many of the crossings shown in the figures 20 and 21, the portions of the paths of the air near to them are not nearly simultaneous, and the positions are merely occupied by different winds in succession, but M and H (Fig. 21) show an example of different character. The Westerly air current represented by M must have reached the point in Lincolnshire where the two trajectories cut very shortly after the air represented by H had passed by; so that the wind must have veered very rapidly from South-west to West. Unfortunately there is no anemograph in this district, so that it is not possible to verify this statement by an appeal to observation. The records from stations possessing anemographs do not as a rule show any such sudden changes of wind direction during the storm. Stonyhurst, however, provides an example; at 3.15 a.m. of the 27th, the wind shifted suddenly from South to South-west.

The Classification of the Storm of February 26-27.

We now return to a consideration of the phenomena represented as bearing upon the classification of the storm under Type B. The classification was based upon a comparison of the trajectories of air in the actual storm as just described with those drawn for an ideal storm, complying strictly with the specification of the type. The classification represents the results obtained from an examination of the phenomena as regards wind. The temperature changes should be considered next. They confirm the suggestion that the air concerned in the various gales came from different places of origin. The most striking record is that for Valencia, which was to the south of the storm centre but not far away from it. There we find the temperature (Fig. 22) a little above 40°, with a West-south-west wind in the forenoon of the 26th. From that time the wind backed with the falling barometer, and with some fluctuations the temperature rose, with rain falling, until a maximum of 51° was reached at 9.30 p.m., with a Southerly gale. The storm centre at that time was to the north-west, so that the wind producing the high temperature was blowing towards the front of the storm. The minimum barometer reading was reached at Valencia very soon after the maximum of temperature; and the wind veered to South-west and subsequently to West, while the temperature had fallen below 45° by 3 a.m. and remained near that figure for a considerable time until a further fall set in, in the afternoon after the storm had passed, with a shift of wind unconnected with the storm. The thermometer maximum is a specially notable phenomenon, as it occurred in the night. Similar phenomena but less conspicuous in degree are to be traced in the records for Southport and Stonyhurst, which were also to the south of the path, and which also show maximum temperatures with the Southerly wind before the passage of the barometric minimum. The rainfall distribution also showed a close analogy, and in many respects there is even similarity in the records for Falmouth, Oxford, and Kew, which were also to the south of the path, much farther from it.

The phenomena are different at Glasgow and Fort William, which were almost under the path of the storm. At Aberdeen, which lay to

the south of the path, a maximum of temperature is shown some time after the passage of the barometric minimum. The causes of the

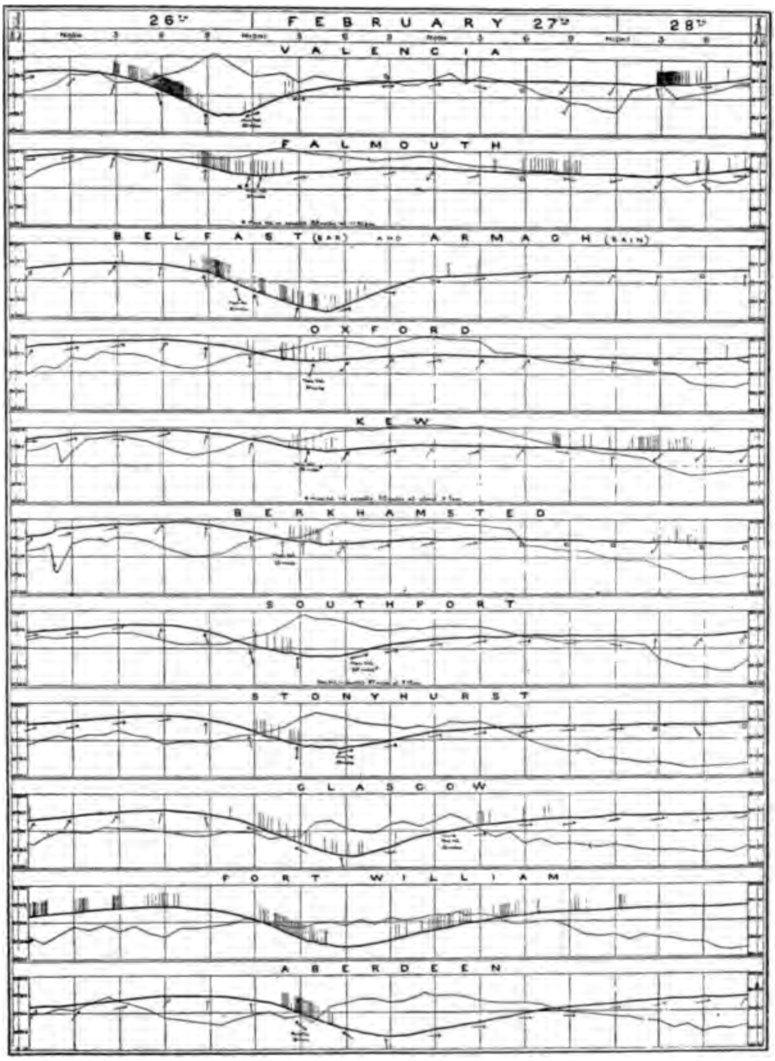

FIG. 22.

The thick line represents the variation of barometric pressure. The irregularities in the line for Valencia, indicate "pumping."
The thin line represents the variation of air temperature.
The direction and force of the wind are represented by the arrows with the addition of some incidental notes as to maximum values.
The occurrence of rainfall is represented by the vertical lines upward drawn from the barometric curve. A line is drawn for each hundredth of an inch for each quarter hour.

temperature changes at these stations must be considered with reference to the paths of the air shown by the trajectories and their connections, and must be a feature of the replacement of the warmer Southerly winds

by the cooler Westerly ones. It is not, perhaps, worth while to pursue the details in this single instance until particulars of corresponding changes in other characteristic storms are available for comparison.

Convection Currents in a Storm of Type B.

It may, however, be desirable to give some further consideration to the influence of convection upon the general phenomena, which presumably must be associated with the production of rain in an ascending warm current and of changes of temperature when the descending current takes its place on the surface.

The evidence of convection currents from the winds and air trajectories of an actual storm may be twofold. First, the convergence of trajectories without any changes of velocity, as represented in Figs. 20 and 21, must cause or be associated with an ascending current, and *vice versâ*. Secondly, a diminution of velocity at the surface in one part of the area may be due to the ascent of air, and an increase of the velocity in another part of the area may be due to a descending current. For evidence of convection currents of the first kind we may turn again to the trajectories represented in Fig. 21. Wherever two trajectories converge in the manner represented, the peculiarity of the motion of the air between them may be accounted for by supposing that the air goes upwards. If we imagine the points on M and H marking the same hour joined, the region between these two trajectories would be divided into a number of quadrilateral figures, the area of which obviously diminishes as we approach the point of intersection. The air that was at a particular instant within any one of these quadrilaterals must have been within its neighbour three hours earlier; and as the areas of successive quadrilaterals diminish in size, the excess of air must have escaped upwards. Conversely, an increase in the size of successive quadrilaterals would be associated with downward motion of the atmosphere.

It will be noticed that the points of convergence lie on the transverse line across the path through the position of the centre, *i.e.* the trough of the storm, and whatever physical results are produced by the divergence and convergence must be looked for in the phenomena occurring shortly before and after the passage of the trough. The physical effect to which appeal would naturally be made is the rainfall which it might be supposed would accompany the upward motion indicated by convergence.

On the maps the positions where rain was recorded as falling are indicated as already mentioned, and the time of occurrence of rainfall at a number of stations is also represented on the diagram, Fig. 22.

It is, however, not possible to make use of all the details of these records with any degree of confidence in the consideration of the effect of the convergence, because we have no information as to how far raindrops are carried after being formed before they reach the earth; but supposing that the rain falls not far from its place of formation, it may be said that although there are cases shown of rain falling in the region of convergence after the passage of the trough, and especially the rainfall associated with the development of the secondary in the south-west of England after the passage of the storm, yet, except at Fort William (see

Rainfall map, Fig. 19) most of the rain in the region of the path of the storm fell during the Southerly or South-easterly gales and strong winds which marked the approach or commencement of the storm.

This leads one to consider the second kind of evidence to be found in the maps for convection during the passage of the storm.

If on passing along the trajectories in the storm a region is reached where air is rising, the surface wind velocity may fall off; and on the other hand, in a region where air is sinking it may show an increase of surface activity. It is possible therefore that the surface trajectories between the places where air rises and where it sinks may show less wind velocity than the trajectories of a storm in which the motion is exclusively horizontal. It has been noticed already that the storm of February 26-27 shows trajectories agreeing remarkably well with those of an ideal horizontal storm, up to the path and again from the path outward; between these two portions those trajectories cannot be traced, but, so far as is known, the wind velocities in that region did not reach gale force.

This circumstance may be accounted for by assuming upward convection in front of the centre, and downward convection behind it. The distribution of rainfall lends some force to this suggestion. It cannot be fully confirmed by observations in the absence of knowledge of the phenomena taking place in the upper atmosphere. In the particular instance under consideration some confirmation is afforded by the observations on Ben Nevis, which was close to the path of the storm. These observations show a North-westerly air current during the early part of the period covered by the maps, when the South-westerly winds were blowing at sea level. As the depression advanced the wind backed, and at midnight it had become South-easterly, agreeing in direction with the lower winds. This South-easterly wind attained the velocity of a gale between midnight and 3 A.M., the highest recorded estimate of the force being 11. The centre passed very close to Ben Nevis; about 5 a.m. its passage is marked by the wind becoming light and variable. This continued till the close of our period; no freshening of the wind from any western or northern point in the rear of the storm was observed at the summit. Thus the storm on the mountain was not of the circular type at all. It may be that Ben Nevis felt the full force of the ascending current from the South, but missed the horizontal force of the descending current which gave the Westerly winds in the rear of the storm at the surface. The changes of temperature accord with such ideas. At 8 p.m. on the 26th the temperature at the summit was 20°, and at Fort William 38°·4. At 8 a.m. on the 27th the temperature at the summit had reached 26°·2 while that at the foot was 39°·3.

If we suppose the surface at 8 a.m. on the 27th to have been supplied by the cold air originally at the Ben Nevis level at the temperature of 20° descending to take the place of the rising air, we should have to account for the difference of 19° by dynamical heating. This would imply a temperature gradient of 0°·43 per 100 feet (or 0°·8 C. per 100 metres), and is thus not far from the adiabatic rate of warming during descent. Such a difference is therefore within the range of possibility.

The classification of the storm of February 26-27 as one of the type

B is accordingly supported, so far as the very limited evidence goes, by the recorded changes in the meteorological elements, provided that we may be allowed to suppose that the air coming out from the back of the storm is a supply of colder air derived from above, and not the same air as that which enters the storm at the front, and which probably passes upward, causing rain.

The examination of a single storm cannot afford more than a mere suggestion with regard to the question whether some external dynamical or thermal agent is necessary for the development or maintenance of a travelling storm. In this particular case the strong and warm Southerly wind frequently referred to, which originally appeared crossing the line of the South-westerly wind, and of which some signs are shown in the Atlantic maps as well as in all the later charts exhibiting the front of the depression, seems to have an existence independent of any local action within the storm area, and may have been a necessary feature of this particular type of storm.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) said that the thanks of the Society were due to Dr. Shaw for his very interesting paper. The rotary theory of the circulation of wind round the centres of storms has been accepted by meteorologists for some years past, but there are novel and valuable suggestions in Dr. Shaw's paper which must influence all future investigations of the dynamic theory of storm movements. It would be interesting to see the further development of Dr. Shaw's ideas; and, as he points out, the number of investigators and of self-registering instruments have increased so considerably, and have accumulated such a mass of authentic information on this subject, it seems time that all existing data should be re-examined, sifted, and classified in a thoroughly scientific manner.

Dr. A. BUCHAN wished to express his high appreciation of the paper. He and the majority of meteorologists had believed for thirty years that the circulation of air round storms was vortical, but he was glad to see in Dr. Shaw's paper a new point of view set forth, and one which must attract close attention. In looking into the phenomena of a storm it was to be observed that the right hand of the centre of the depression was generally warmer and moister than the left, and this precluded the idea of vortical movement. American observers had thrown out hints to this effect, and Dr. Shaw had shown further evidence in the same direction, and, in fact, thrown this branch of meteorology back for re-examination. The Meteorological Office had been of great use in going into detailed investigations, and Dr. Shaw and Mr. Brodie had done this with great ability. If he (Dr. Buchan) could give any assistance in the work he should have much pleasure in doing so. He thought these investigations should lead to important results.

Mr. R. T. OMOND said there was one point in Dr. Shaw's paper which he had not quite understood, and that was whether the wind which blows outward from a circular storm is the same wind, reversed, as that which blows into it.

Dr. W. N. SHAW.—No, the X's go in and the Z's come out. They may be made of quite different air on account of upward and downward convection.

Mr. OMOND thought the paper upset the previously accepted theories about cyclones, and suggested re-investigation of the subject.

Col. H. E. RAWSON, R.E., said that, with the rest of the Fellows present, he wished to express his appreciation of the paper which Dr. Shaw had given, and

the skill with which it had been presented. The diagram of Type B carried much conviction to his mind, as it contains the explanation of two characteristics which he had for twenty-five years found to be associated with certain types of cyclonic storms. He took much interest in such storms when he was quartered in the West Indies, and obtained accounts from eye-witnesses of the peculiar destruction caused by two of them. One of them swept through a wood, levelling every tree in the same direction for a breadth of 100 to 150 yards only, and finishing up with a church steeple. The other passed over a wood, showing a waltzing and at the same time wave motion. It descended on a spot, laid every tree low in a tangled mass, and rising up passed on to another spot where it did the same thing. The area levelled was described as small, and not a branch was broken of the intervening belt of trees. These characteristics were strongly marked in these two different storms, and he had heard of them several times since—the narrow belt of trees all laid low in the same direction throughout the whole path of the storm, and the tangled mass of trees lying in all directions, separated by trees showing no signs of the storm. But in the storm of February 1903 he obtained from the neighbourhood of the Curragh Camp and Dublin most convincing evidence that both characteristics were combined, and for the first time he felt satisfied that they might belong to different parts of the same storm. Dr. Shaw's diagram shows how this may be, and he welcomed it as marking one more step towards a proper understanding of storms of this kind. Major Hutchinson, Resident Magistrate County Kildare, a reliable observer, wrote to him (Col. Rawson) from the Curragh : " On the morning after the storm, when passing over the high ground above Windy Gap, I noticed extraordinary circular marks on the turf. At first it seemed as if horses had broken away with a plough and run round in circles, cutting deeply into the ground in places, and only scratching in others. Some of the cuts or scoops were 6 and 8 inches deep. I could not fancy what caused these marks, until, going about 60 or 70 yards farther, I saw that the corrugated roof of the civilian canteen was gone, and that it was the roof that had been waltzing over the Curragh during the storm. Some of the circles were 20 feet in diameter, others larger." He also noticed how the storm appeared to swoop down on the middle of a plantation, snapping off and rooting up trees, while the edges had not suffered. Large elms were found blown down towards the north-east, and within 20 yards an equally large elm lay facing the south.

The hurricane of February 26-27 was the most severe in Dublin since January 6-7, 1839. Both were at their height from about 2 to 4 a.m., and as the particulars of the latter may be of interest he had extracted them from the records of the Ordnance Survey Office, Phœnix Park.

	Bar. corrected.				Thermometer.				Wind.			
1839.	9 a.m.	Noon.	8 p.m.	9 p.m.	9 a.m.	Noon.	8 p.m.	9 p.m.	9 a.m.	Noon.	3 p.m.	9 p.m.
	in.	in.	in.	in.	°	°	°	°				
Jan. 6 .	29·293	29·111	28·994	28·554	37·0	39·0	41·0	51·5	SW.	S.	W.	W.
,, 7 .	28·721	28·753	28·863	...	40·0	40·5	40·5		SW.	SW.	W.	

The rainfall recorded for the period of the storm was only 0·115 in. On January 6, at 3 p.m., it was very dull and gloomy, with a light breeze ; at 9 p.m. it was blowing a gale, with drizzling rain, but stars to the east. The rise of temperature at this hour is noticeable. By midnight a very strong gale was blowing, with rain.

Mr. W. Ellis said that he desired to thank Dr. Shaw for his interesting paper, although he had little to offer in the way of remark thereon, as it dealt with a branch of meteorology to which he had not had opportunity of paying

much attention. It was interesting to find original thought directed to the phenomena of storms which should be likely to lead to important results.

Mr. F. J. Brodie observed that he was not prepared to add anything to the lucid explanation Dr. Shaw had given of the methods employed in the preparation of the paper. The facts advanced threw a new light upon the circulation of air around a storm system, and afforded much ground for reflection. He (Mr. Brodie) would suggest that a similar treatment be applied to storms of various types, and particularly to those in which the cyclonic circulation was more complete than it was in the case of the February gale. In this way we might arrive at a fuller confirmation of Dr. Shaw's views, and might also gain additional information as to the laws governing the motion of storm systems in general. Such inquiries held out great promise of results which would be of real practical value to those engaged in the difficult work of forecasting the movements of storms and of less important weather systems.

Dr. A. Buchan stated that twenty years ago he had collected information from all quarters concerning a storm in Scotland, and had noted one rather remarkable incident, viz. that the destruction of all trees lay entirely in one direction. The Duke of Buccleuch's property particularly had suffered. On another occasion two silver firs growing amidst low shrubs had been torn (or gouged) out of the earth, and were lying uprooted, while the shrubbery around them was untouched by the gale.

Dr. H. R. Mill thought that the paper was not unlikely to unsettle the convictions of meteorologists concerning cyclones. He hoped that Dr. Shaw would proceed with the investigations and develop a theory, for the theory of cyclones at present in favour was difficult and unsatisfactory in many ways.

He (Dr. Mill) had frequently observed that the heaviest rainfall occurred to the right of the path of a storm. Floats were frequently used in investigating currents in the ocean, and although we cannot cast floats into the atmosphere the experiment sometimes occurs naturally by the transport of dust. It was interesting to notice that in discussing the dust-fall of March 1901 Professors Hellmann and Meinardus showed that the dust travelled northward simultaneously with the movement of a small depression from the Mediterranean to the Baltic, and on the right of the track of the centre. Hence they concluded that a current of Southerly wind accompanied the depression on the right, while a current of Northerly wind prevailed on the left. He could not recollect ever having heard a paper so full of the promise of advancement in meteorology, and he felt that Dr. Shaw deserved special thanks for making a meeting of this Society the occasion of its publication.

Mr. W. H. Dines said that he thought Dr. Shaw's paper would mark a new epoch in the study of these storms, and the curves he had shown certainly fitted in well with the actual wind directions of the gale of February 26-27. He would suggest that the rainfall might be taken as a perfectly true guide to the locality and extent of the upward current, for it seemed clear that the adiabatic cooling produced by a decrease of pressure was the only cause capable of producing any, save the smallest, quantity of precipitation; and hence rain might be accepted as trustworthy evidence of an upward current, however this upward current might be produced. The temperature conditions did not seem to him to support the idea that the same air descended in the rear of the storm and formed the West and North-westerly winds, for these winds were cold, whereas, like the Föhn wind, they ought to be warm and very dry. With reference to the rise in temperature that occurred in front of a storm, he could not see that it presented any difficulty. The storms nearly always moved from some westerly point, and the winds in front were from some southerly point. That South winds were warm was common knowledge, as old at least as the time of Job, and this seemed to him amply to account for the rise of

temperature. Dr. Shaw had referred to some experiments of Mr. Aitken, and suggested that the storms might be eddies in the general current. There was no doubt about the prevalence of a strong and persistent upper current from some westerly point throughout both the temperate zones, but he (Mr. Dines) did not believe in the eddy theory, and for this reason. Eddies were produced by obstacles, and therefore storms ought to be most frequent where there were most obstacles, that is to say on the lee side of high mountain ranges running north and south, such as the Rocky Mountains. As a matter of fact, however, storms were most frequent in latitudes of about 40° to 50° over the Southern Ocean, and next to this over the North Atlantic, the two localities of the temperate zones where there are no obstacles of any kind. It seemed to him far more likely that they owed their origin to convection currents tending to equalise the potential temperatures of the different air strata.

Mr. C. Harding was impressed by the amount of material for thought contained in the paper. For years meteorologists had been building up bricks, and the master builder appeared to be Dr. Shaw. One remark he had to make about the depressions or cyclones was that as a general rule the high pressure keeps upon their right hand side, and this had especially been the case with the storms of the last few days. It was a fact that sailors regarded the North-west wind as worse than the South-west, because the North-west took a downward current and struck the surface of the sea, producing heavy broken waves. The paper was of a nature exceedingly hopeful for future advance in meteorology.

Capt. A. Carpenter asked if it was not very unusual for the centre of a cyclone to travel onwards as fast as the force of its component winds? For instance, a cyclone, whose wind force averages 30 miles an hour, progressing onwards at a rate of 30 miles an hour. If the cyclone was progressing onwards as a whole it might perhaps be likened to a wound-up top allowed to run down its string in a horizontal position. It is obvious that in such a case a point on the circumference of the top would describe a greater distance in its descent than the mere height of the hand from the ground. The very fact that a cyclone can occur such as Dr. Shaw has described, whose centre travels as fast as its wind force, shows that the gyratory action is different from that of a top, and that the eddy is the probable cause of the wind, and not the wind the cause of the eddy.

Mr. W. Marriott mentioned that in the *Quarterly Journal* would be found weather charts for three-hour intervals (vol. x. p. 114), and also hourly maps for 11 consecutive hours (vol. i. p. 188).

Dr. W. N. Shaw, in reply, said he would deal with Capt. Carpenter's remarks first. He was not prepared to allow the force of the analogy of the rotation of a top with that of a storm. A top was of the same material throughout, whereas in a cyclone the material was continually changing.

Regarding Dr. Mill's suggestions he (Dr. Shaw) had no wish to add another to the theories of storms—there were too many of these already. What we wanted was increased knowledge of the facts, and he was dealing only with the facts and their classification. He was glad to hear what Mr. Dines had said in reference to rain and to the air temperature at the back of a storm. He had had the rain areas carefully marked on maps in order to ascertain the distribution of rainfall on those occasions. Further consideration of the point had been arrested by the difficult question, Given the locality in which a cloud of drops forms, how far will they travel in a gale blowing at the rate of 50 miles an hour before they reach the earth? With regard to the temperature at the back of a storm being lower than that in front, he thought explanation of this had been given in the course of the discussion of the results of the kite observations with Mr. Dines. The air which descends in a storm will be colder

than that which goes up, in spite of dynamical warming; because in the end, after exchange has taken place, it must be the coldest air that will find itself at the bottom.

He desired to thank the Fellows for speaking of his paper so kindly as they had, but thanks were due to others as well as himself, and to Mr. Lempfert and Mr. Brodie in particular.

The Meteorological Service of the Philippine Islands.—Part II. of the *Report of the Director of the Philippine Weather Bureau* is devoted to a paper on the Meteorological Service of the Philippine Islands, in which the Rev. Marcial Solá, S.J., gives a Report of its Establishment and Development under the Spanish Government and its Reorganisation under the Government of the United States, 1865-1902.

The Manila Observatory began its work in the year 1865 at the college known as the Ateneo, under the direction of the Fathers of the Society of Jesus. This date may be given as the beginning of the Philippine Meteorological Service, not only because before that time there was no other institution in the Philippines engaged in the study of meteorology, but for a long time previous the professors of that college had dedicated themselves to the study of predicting the existence and course of the cyclonic storms which are so frequent in the archipelago. At first only a few instruments were installed, for the observation of the principal meteorological elements, and a small monthly leaflet illustrated with various curves giving the results obtained was issued. In time, owing to donations made by private individuals who were anxious to see the Observatory improved, a complete collection of apparatus for direct observation was acquired.

As the data gathered day by day became more complete, the Observatory, in the year 1870, began to publish, in place of the leaflet mentioned above, a monthly *Bulletin*. This publication contained, besides scientific discussions, the results of the daily meteorological observations taken at three-hourly intervals. In 1879 the Manila Observatory issued their first typhoon warning on July 7 of that year. In 1880, after Manila was connected with Hong-Kong by cable, various warnings were sent to that colony. In 1881 the Observatory was recognised by Royal Decree, and a series of stations was organised. A new Observatory was built, with meteorological, magnetical, and astronomical departments, the two former having been at work continuously since 1886 and 1888 respectively.

During the war in 1898-99 the work of the Observatory was kept up without interruption. After the war, the work of reorganising the Meteorological Service on lines laid down by the Weather Bureau at Washington was taken in hand. The Service now consists of the Central Observatory at Manila, 9 First Class Stations, ?5 Second Class Stations, 17 Third Class Stations, and 21 Rainfall Stations. In March 1899 a new monthly publication, *Climatological Data for Manila*, was issued. In the beginning it contained only the more interesting meteorological data of the month, with a discussion of the same. In 1901 a résumé of the magnetical observations was added, and at the present seismical notes are also added.

The Report is worth reading, and contains a detailed account of the instruments in use at the Observatory and stations as well as much other interesting matter, also a complete list of the publications of the Observatory.

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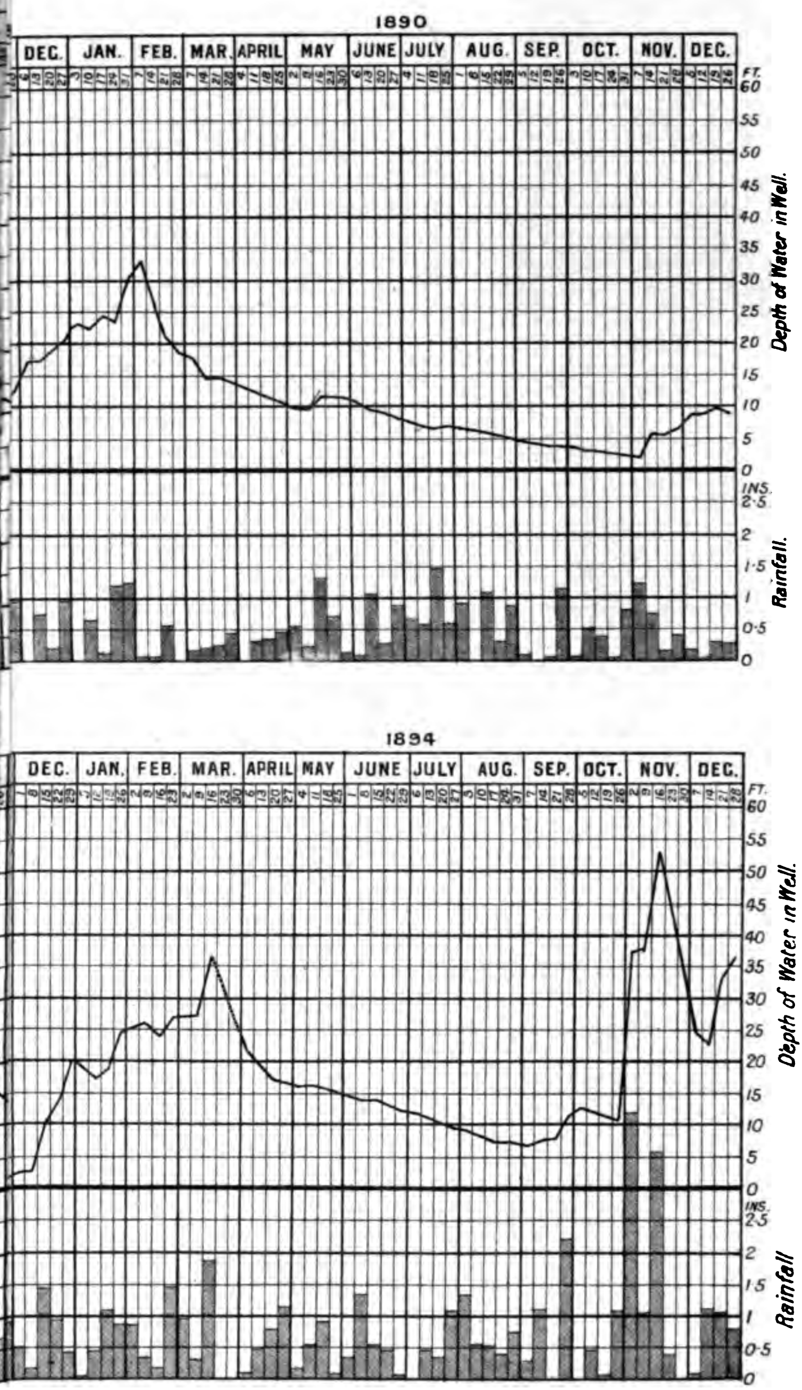
1890
DEC. JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.
FT.
Depth of Water in Well.
INS.
Rainfall.
1894
DEC. JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.
FT.
Depth of Water in Well.
INS.
Rainfall

THE RELATION OF THE RAINFALL TO THE DEPTH OF WATER IN A WELL.

By CHARLES P. HOOKER, L.R.C.P., F.R.Met.Soc.

(Plates IV. and V.)

[Read May 20, 1903.]

I HAVE been fortunate enough to obtain the measurements, taken weekly since 1886, of the depth of water in a well near where I reside, and it occurred to me that it might be of some practical use to compare them with the rainfall of the same period, with a view to determining what effect the latter might have on them. My reasons for bringing the results to the notice of the Society are: firstly, because, with the exception of the Rothamsted experiments on percolation (*Quarterly Journal*, vol. xxvi. p. 139), which do not go beyond a depth of 5 feet, I do not know of any published records bearing on the subject; secondly, because it seems to me that further investigations ought to be made in other places, particularly those from which large quantities of water are drawn for our already densely populated and rapidly growing towns; and, thirdly, because I venture to think that some of the results shown are contrary to our preconceived views on the subject.

There has scarcely been one year recently in which, in some part or other of England, the water-supply has not run short, and the rainfall always has the blame, whereas it is surely our method of dealing with it that is at fault. It is easy to say that the last decade or so has been characterised by a rainfall less than the average; but if we run short for so small a cause, it only shows how narrow the boundary is between sufficiency and want, and that if we go on needing more and more water every year—which we do—the time cannot be far distant when even an average rainfall will not suffice.

The constantly increasing drainage of the soil by the tapping of large areas for town supplies, and the abstraction of vast quantities of water from the rivers, thus lowering their level, and tending to make them drain the surrounding land more rapidly, so that wells, especially those situated in their proximity, have to be frequently deepened, cannot go on with impunity.

It is impossible for the ground to hold more than a certain quantity of water, and I hope to show that this amount is not being constantly renewed, but usually only in the winter months. Yet in winter we allow the rain to run to waste, and appear only too anxious to get rid of that which we sorely need in summer.

The well with which I propose to deal is situate in the kitchen of a house in the suburbs of Cirencester, named "Further Barton," owned and occupied by Miss Brown, to whose kindness I am indebted for free access to all her records. I should like also to acknowledge my thanks to my brother, Mr. Reginald Hooker, for much valuable assistance, especially in the compilation of the tables.

The Further Barton is situated on an elevated plateau about 60 feet above the town, which is at the foot of the Cotswold Hills.

With the exception of a very insignificant quantity, no water has been drawn from the well during the period under review.

The height above sea-level of the well mouth is 421 feet, and it is 101 feet deep. The upper 60 feet pass through the loose oolitic rock of the district, the lower 41 feet through Fuller's earth: this forms a large bed extending over several square miles of varying depth and thickness, so that the well dips as it were into a large water-holding area, from which the Thames itself rises. In fact, the well is only about two miles from what is known as Thames Head, and the flow of the underground water is probably in that direction. The depth of water in the well is measured every Friday morning about 11 o'clock, and the rainfall with which it is compared in the tables is that which has fallen in the week preceding, including that measured the same morning at the usual hour, 9 o'clock.

I am aware that other local factors besides those enumerated below might have an influence, but I can trace none which have any on this well. Nor do I wish to imply that other wells would necessarily show the same results; it is quite probable they would not.

The chief factors influencing the depth of the water are:—1. The Rainfall; 2. The Season of the Year; 3. The Amount of Evaporation; 4. Periods of Drought; 5. Frost and Thaw; and 6. The Effects of Vegetable Growth.

1. *The Rainfall.*—The amount of rain that falls in a year is no safe guide as to how much water there will be in this well; more depends on the character and regularity of its fall. It is evident that a steady, prolonged, soaking rain is more likely to penetrate than an equally heavy fall confined to a short period, a large proportion of this latter flowing off the surface into the streams. What has most effect is two or three weeks of heavy rainfall in succession.

2. *The Season of the Year.*—Winter rains are of a far more penetrating character than those of summer. They usually have in their favour a soil already moist, through which to percolate, practically no evaporation and no vegetable growth to contend with.

In spring evaporation is becoming large, and there is also plant growth, but the soil, and certainly the subsoil, is still moist.

In summer evaporation is at its highest, and by rapidly drying the soil prevents the rain from penetrating, what does not evaporate being all utilised in merely moistening a section of the soil. Plant growth too is at its maximum.

In autumn evaporation is much less; plant life is ceasing, and the usual heavy rains surely, though perhaps slowly, moisten the earth and the water passes through.

3. *Evaporation.*—There are some extremely interesting records of evaporation from earth and water tanks published yearly in *British Rainfall*, which show most markedly what a large amount of our summer rains must be lost from this cause; but they are not of much assistance in determining how much takes place from the earth itself, so many varying factors being present in different localities, such as the depth of surface soil and its character, the presence of vegetation, the lie of the ground, etc. Assuredly in the summer months the evaporation must be, under ordinary conditions, nearly equal to the sum total of the rainfall;

and were it not that we get wet periods in which the rainfall is much in excess of what has previously evaporated, it is quite probable that summer rains would never penetrate to the well at all; in some years they certainly seem not to do so.

4. *Periods of Drought.*—The steady decrease in the level of the water during droughts is well shown by the charts, and it is evident, by comparing a winter drought with one occurring in summer, that mere absence of rain has not the same permanent effect in the former as it has when coupled with the heat and evaporation of the latter.

A sinking of the water-level in the well in February is easily recovered from, because the soil is still damp; but that occurring in a summer month is more lasting, as the soil has become dry and rains do not percolate through. How slowly rain penetrates after a hot dry period every gardener knows; it takes several days of steady, heavy rains to sink even a short distance in the surface soil.

5. *Frost and Thaw.*—When the surface is frozen, moisture does not penetrate and the water-level in the well falls, but slowly. The snow which falls mostly remains till the thaw, and though when that comes much water is undoubtedly lost by surface running till the earth is completely thawed, still the rapid rise of level that takes place shows that a large amount reaches the well. As these only occur in the winter months and appear to have no permanent effects, they are not, I think, of much practical importance as regards our present subject.

6. *Vegetable Growth.*—This certainly has a large effect, but one very difficult to estimate.

Table I. and Plates IV. and V. show the depth of water in the well for each week, with the corresponding total rainfall, taken at the house, of the previous seven days. And I wish that I could show the measurements of both taken daily, but as the well depth is only gauged once a week, I cannot do so. Perhaps my remarks may induce some one with better opportunities to take daily observations. I feel sure that more accurate results would be obtained, as the water has time to rise and fall between measurements taken only weekly.

The first thing that strikes us on looking at the charts is their general similarity, the exceptions being few.

There is as a rule a maximum in one of the first three months of the year, followed by a minimum in August, September, October, or November, the favourite time being apparently the end of October or beginning of November, which coincides fairly with the cessation of evaporation and plant growth. What might be called a fairly normal curve would be one in which a maximum in January or February is followed by a gradual downward sweep, with some interruptions in the early spring, to a minimum at the end of October, when a rather abrupt rise takes place to a comparatively high level by the end of the year. Such a fairly normal curve is that of the first year shown, 1887.

It is interesting to notice that a *mathematical* curve of the average depth in each week of the period shows a minimum about the latter part of August, which is in reality an event of rare occurrence. In this average curve the normal course of events is masked by one or two exceptionally high water-levels (*e.g.* 1891) occurring in late summer,

TABLE I.—RAINFALL OF PRECEDING SEVEN DAYS, COMPARED WITH DEPTH OF WATER IN THE WELL.

Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.
1887	in.	ft. in.	1888	in.	ft. in.	1889	in.	ft. in.	1890	in.	ft. in.
Jan. 7	·86	33 10	Jan. 6	·37	19 5	Jan. 4	·02	36 9	Jan. 3	·01	23 2
14	·87	37 4	13	·09	18 3	11	·37	28 3	10	·69	22 8
21	·73	47 7	20	·02	17 5	18	·08	24 2	17	·12	24 5
28	·30	38 2	27	·29	16 5	25	·09	21 6	24	1·26	23 9
Feb. 4	·67	28 5	Feb. 3	·11	15 4	Feb. 1	·36	18 8	31	1·26	29 8
11	·01	27 8	10	·04	14 5	8	·70	20 0	Feb. 7	·01	32 8
18	·13	23 8	17	1·58	13 6	15	·73	24 8	14	·02	25 10
25	·16	20 8	24	·12	13 6	22	·26	28 7	21	·59	20 10
Mar. 4	·01	18 9	Mar. 2	·06	12 4	Mar. 1	·06	25 5	28	·01	18 7
11	...	16 7	9	·58	19 3	8	1·42	18 1	Mar. 7	·17	17 5
18	·73	14 8	16	1·41	40 9	15	1·07	38 10	14	·23	14 10
25	·48	15 3	23	·26	33 6	22	·30	30 10?	21	·24	14 11
Apr. 1	·43	17 11	30	1·23	34 4	29	·14	23 9	28	·45	14 0
8	·16	16 9	Apr. 6	·23	31 1	Apr. 5	·53	20 5	Apr. 4	...	13 0
15	...	15 8	13	·22	25 3	12	·97	23 8	11	·31	12 3
22	·02	14 6	20	·83	21 7	19	·16	24 0	18	·37	11 6
29	1·15	14 0	27	·35	19 11	26	·82	21 7	25	·48	10 10
May 6	·48	17 1	May 4	1·15	20 1	May 3	·45	21 3	May 2	·56	9 11
13	·20	16 3	11	·07	21 8	10	·23	19 10	9	·21	9 6
20	·45	15 7	18	·75	20 6	17	·38	18 4	16	1·32	11 4
27	·38	14 0	25	·02	17 10	24	·11	17 4	23	·72	11 6
June 3	1·36	12 4	June 1	·45	16 6	31	2·48	26 3	30	·13	11 1
10	·21	15 4	8	·38	15 1	June 7	·62	26 4	June 6	·07	10 6
17	...	12 10	15	·74	14 1	14	·29	22 8	13	1·04	9 8
24	...	13 3	22	·93	12 11	21	·05	19 5	20	·27	9 3
July 1	...	12 4	29	·59	12 0	28	...	17 2	27	·87	8 7
8	·18	10 6	July 6	1·13	11 5	July 5	...	14 10	July 4	·67	7 8
15	·25	10 8	13	·47	10 10	12	·90	13 4	11	·58	7 1
22	·07	9 10	20	1·14	10 2	19	1·24	12 10	28	1·46	6 7
29	·51	9 1	27	1·04	12 0	26	·71	11 9	25	·60	7 0
Aug. 5	...	7 11	Aug. 3	1·05	18 6	Aug. 2	·02	10 11	Aug. 1	·89	6 6
12	·09	7 4	10	·20	18 2	9	1·16	9 6	8	·01	6 3
19	·47	6 6	17	·05	17 5	16	·89	8 11	15	1·05	5 7
26	·11	6 3	24	·60	15 3	23	1·17	7 10	22	·27	5 4
Sept. 2	·95	5 9	31	1·28	13 10	30	·27	7 8	29	·83	4 11
9	1·18	5 0	Sept. 7	·22	12 8	Sep. 6	·11	7 1	Sep. 5	·09	4 7
16	·21	4 9	14	·24	11 2	13	...	6 7	12	...	4 0
23	·55	4 11	21	·01	9 10	20	·24	6 4	19	·04	3 10
30	·35	4 3	28	·56	8 9	27	1·42	5 11	26	1·12	3 9
Oct. 7	·09	3 10	Oct. 5	·27	8 4	Oct. 4	·11	5 5	Oct. 3	·03	3 5
14	·26	3 3	12	·06	7 9	11	·51	5 2	10	·50	2 10
21	·05	3 3	19	·04	7 0	18	·18	4 11	17	·35	2 11
28	·55	2 11	26	·08	6 6	25	·63	4 6	24	·03	2 5
Nov. 4	2·69	4 5	Nov. 2	·85	5 11	Nov. 1	·85	5 6	31	·76	2 1
11	1·00	10 9	9	1·32	7 11	8	·56	7 1	Nov. 7	1·22	2 0
18	·03	12 8	16	1·82	19 1	15	...	11 6	14	·75	5 7
25	·51	13 10	23	·29	27 10	22	·22	10 8	21	·13	5 8
Dec. 2	·04	15 2	30	1·81	29 2	29	·92	12 9	28	·39	6 1
9	·74	15 0	Dec. 7	·75	33 10	Dec. 6	·01	17 1	Dec. 5	·18	8 10
16	·98	15 1	14	·74	34 3	13	·77	17 4	12	·02	8 11
23	·27	20 6	21	·24	27 10	20	·20	18 8	19	·29	9 5
30	·09	23 7	28	2·18	30 3	27	·93	20 2	26	·22	8 6

TABLE I.—Rainfall of Preceding Seven Days, Compared with Depth of Water in the Well—*continued.*

Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.
1891	in.	ft. in.	1892	in.	ft. in.	1893	in.	ft. in.	1894	in.	ft. in.
Jan. 2	·08	8 1	Jan. 1	·97	29 0	Jan. 6	...	17 7	Jan. 5	·03	18 6
9	·09	7 7	8	·14	28 0	13	·41	16 2	12	·40	16 4
16	·03	8 8	15	·15	24 1	20	·40	17 6	19	1·09	17 9
23	·35	11 3	22	·71	22 6	27	·54	18 6	26	·81	24 2
30	1·96	28 0	29	·21	25 4	Feb. 3	1·21	29 5	Feb. 2	·80	24 10
Feb. 6	·53	32 3	Feb. 5	·25	23 4	10	·23	29 2	9	·31	25 10
13	...	27 0	12	·31	21 1	17	·90	26 3	16	·13	23 4
20	...	21 1	19	·39	19 11	24	1·00	35 0	23	1·42	26 2
27	...	18 9	26	·67	23 3	Mar. 3	·88	34 8	Mar. 2	·97	26 9
Mar. 6	·02	16 3	Mar. 4	·01	23 8	10	·10	30 5	9	·29	27 0
13	·80	14 9	11	·10	21 4	17	·04	24 9	16	1·89	35 6
20	·61	22 8	18	·54	19 0	24	·02	20 10	23	...	30 0?
27	·13	22 11	25	·01	18 7	31	...	18 5	30	...	24 7
Apr. 3	·08	20 3	Apr. 1	·05	17 3	Apr. 7	·02	16 8	Apr. 6	·09	20 4
10	·64	18 3	8	...	15 9	14	...	15 0	13	·45	17 5
17	·05	17 9	15	·35	14 9	21	·03	14 3	20	·80	16 1
24	·05	16 0	22	·40	13 9	28	...	13 2	27	1·15	15 2
May 1	·24	14 6	29	·19	12 7	May 5	·03	11 9	May 4	·17	15 1
8	1·00	14 0	May 6	·07	11 9	12	...	11 1	11	·52	15 10
15	·04	13 7	13	...	11 2	19	1·12	10 2	18	·89	14 8
22	1·53	13 0	20	·19	10 6	26	·28	9 2	25	·07	14 4
29	1·23	23 5	27	·27	9 5	June 2	·03	8 7	June 1	·31	13 6
June 5	·33	20 7	June 3	1·16	8 9	9	·12	7 9	8	1·33	13 4
12	...	19 4	10	·42	8 6	16	·12	7 1	15	·52	13 8
19	·24	16 11	17	·01	7 9	23	·10	6 6	22	·42	12 4
26	·76	15 0	24	1·24	7 0	30	·64	6 1	29	·03	11 1
July 3	1·24	13 6	July 1	·34	6 9	July 7	·28	5 6	July 6	...	11 2?
10	1·46	13 7	8	1·05	6 3	14	1·35	5 5	13	·44	10 2
17	·01	11 9	15	1·24	6 2	21	·86	5 1	20	·30	9 8
24	·25	11 5	22	·93	5 11	28	·58	4 7	27	1·08	8 11
31	1·07	10 0	29	...	5 11	Aug. 4	1·54	4 9	Aug. 3	1·32	8 11
Aug. 7	·58	8 9	Aug. 5	·01	5 2	11	·41	4 6	10	·53	7 7
14	·76	8 8	12	·71	4 10	18	·02	4 2	17	·51	7 0?
21	1·59	8 3	19	·38	4 4	25	·34	3 8	24	·35	6 6
28	2·50	16 2	26	·32	4 2	Sept. 1	·04	3 0	31	·73	6 8
Sept. 4	·81	32 10	Sept. 2	1·70	4 3	8	·03	2 8?	Sept. 7	·26	6 5
11	·17	23 3	9	·12	4 1	15	·06	2 5	14	1·10	7 1
18	·97	22 4	16	·04	3 9	22	·04	1 6	21	·01	7 2
25	·51	18 8	23	1·05	3 3	29	·42	1 3	28	2·21	11 4
Oct. 2	·66	17 7	30	1·39	3 9	Oct. 6	1·46	1 10	Oct. 5	...	12 7
9	2·18	28 0	Oct. 9	·22	4 9	13	·71	1 8	12	·42	11 6
16	2·43	30 6	14	·68	5 0	20	·50	1 3	19	·04	11 0
23	2·95	50 2	21	·20	5 7	27	·50	1 3	26	1·05	10 4
30	·44	40 1	28	1·84	6 10	Nov. 3	·29	1 1	Nov. 2	4·19	37 0
Nov. 6	·02	28 8	Nov. 4	·52	18 6	10	·11	8	9	1·02	37 5
13	1·33	27 3	11	·89	26 6	17	·51	1 5	16	3·60	52 1
20	·46	31 6	18	·52	22 10	24	·84	1 4	23	·38	40 11
27	·20	28 1	25	·54	25 1	Dec. 1	·49	2 4	30	...	30 6
Dec. 4	1·15	30 7	Dec. 2	·70	24 7	8	·16	2 8	Dec. 7	·04	24 6
11	1·21	35 4	9	·51	23 10	15	1·45	10 6	14	1·09	22 4
18	1·11	44 1	16	·19	23 5	22	·87	14 2	21	1·06	33 1
25	·02	30 7	23	·01	22 3	29	·40	20 0	28	·77	35 8
			30	·01	19 8						

TABLE I.—RAINFALL OF PRECEDING SEVEN DAYS, COMPARED WITH DEPTH OF WATER IN THE WELL—*continued.*

Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.
1895	in.	ft. in.	1896	in.	ft. in.	1897	in.	ft. in.	1898	in.	ft. in.
Jan. 4	·30	28 7	Jan. 3	·47	27 9	Jan. 1	1·07	33 11	Jan. 7	·54	34 10
11	·15	22 6	10	...	24 9	8	·63	29 0	14	...	28 5
18	1·18	29 9	17	·19	21 4	15	·92	39 3	21	...	23 5
25	1·37	44 9	24	·03	18 11	22	·09	28 10	28	...	19 4
Feb. 1	·27	32 3	31	·49	17 1	29	·04	23 3	Feb. 4	·18	17 11
8	...	25 3	Feb. 7	...	16 7	Feb. 5	2·19	29 10	11	·34	16 0
15	...	20 9	14	·13	15 10	12	1·27	42 4	18	·28	13 8
22	...	18 8	21	·21	14 11	19	·09	35 3	25	·35	14 10
Mar. 1	·11	17 1	28	·02	13 7	26	·49	28 11	Mar. 4	·34	14 10
8	·25	16 3	Mar. 6	·72	13 4	Mar. 5	1·60	32 6	11	·02	14 5
15	·53	17 11	13	·64	17 4	12	·53	33 6	18	·04	14 1
22	·13	19 5	20	·66	20 9	19	1·37	34 7	25	·32	13 0
29	1·16	18 7	27	·59	23 7	26	·28	33 6	Apr. 1	·08	11 3
Apr. 5	·31	28 5	Apr. 3	·23	21 1	Apr. 2	·45	25 11	8	·03	10 4
12	·10	23 11	10	·03	18 7	9	·68	21 10	15	1·32	10 11
19	·07	20 1	17	·81	16 1	16	·68	21 6	22	·01	11 4
26	1·81	19 3	24	·08	14 10	23	·78	25 8	29	·31	10 8
May 3	·46	26 2	May 1	·01	14 1	30	...	23 4	May 6	1·19	10 6
10	...	23 4	8	...	12 8	May 7	·10	20 3	13	·32	17 2
17	...	19 8	15	...	11 7	14	·11	17 9	20	·89	14 2
24	·08	17 4	22	·30	10 5	21	...	15 11	27	·83	17 9
31	·81	15 4	29	·02	9 7	28	·10	14 5	June 3	·19	17 8
June 7	·45	14 3	June 5	·55	9 1	June 4	1·29	13 8	10	·24	15 6
14	·08	12 11	12	·77	8 6	11	1·06	12 10	17	...	12 1
21	...	12 0	19	·38	7 11	18	·35	11 4	24	·27	12 0
28	·04	11 3	26	·47	7 5	25	·35	11 7	July 1	·46	10 7
July 5	1·03	10 5	July 3	·18	6 10	July 2	·91	10 10	8	·48	10 0
12	·09	9 9	10	·20	6 4	9	·09	10 2	15	·01	9 3
19	·38	8 11	17	...	5 9	16	...	9 2	22	·04	6 9
26	2·15	8 9	24	·07	5 4	23	1·53	8 6	29	·26	4 10
Aug. 2	·25	9 4	31	·20	5 0	30	·22	7 10	Aug. 5	1·84	6 9
9	1·23	8 10	Aug. 7	·11	4 7	Aug. 6	·02	7 2	12	·22	5 8
16	1·10	8 8	14	·04	4 3	13	1·39	6 7	19	·40	6 4
23	·18	8 9	21	·38	3 10	20	·85	6 2	26	·07	5 2
30	·40	8 1	28	·72	3 3	27	·94	5 11	Sept. 2	·47	5 1
Sept. 6	...	7 3	Sept. 4	1·42	2 10	Sept. 3	2·94	8 5	9	...	5 0?
13	·76	6 7	11	2·29	3 2	10	·83	10 0?	16	...	4 7
20	·03	5 10	18	1·79	1 11[1]	17	...	12 9	23	·13	3 7
27	·05	5 5	25	2·11	9 8	24	·39	12 8	30	·84	3 8
Oct. 4	·66	4 10	Oct. 2	·49	20 9	Oct. 1	·07	10 8	Oct. 7	...	2 10
11	1·33	5 1	9	1·98	22 4	8	·13	10 8	14	·37	1 1
18	·11	5 0	16	·46	27 8	15	·24	9 6	21	2·82	3 8
25	·52	4 8	23	·17	22 6	22	1·35	11 1	28	·32	4 9
Nov. 1	·25	4 7	30	1·20	26 10	29	·03	12 1	Nov. 4	·93	4 11
8	2·03	8 6	Nov. 6	·03	23 7	Nov. 5	...	10 10	11	·12	9 7
15	1·68	27 8	13	·14	19 10	12	·29	10 1	18	·53	9 5
22	1·02	30 8	20	·76	18 6	19	·37	9 1	25	1·29	12 2
29	·70	25 9	27	·02	18 2	26	·10	8 6	Dec. 2	·52	23 10
Dec. 6	·60	30 6	Dec. 4	·49	17 3	Dec. 3	1·01	12 3	9	1·54	27 3
13	·77	25 2	12	·85	23 5	10	·69	18 10	16	·04	29 8
20	·64	28 1	18	·64	29 1	17	1·87	32 4	23	·40	24 0
27	·47	25 8	25	·73	25 11	24	·01	30 10	30	1·08	21 9
						31	1·73	30 11			

[1] This seems a doubtful reading.

TABLE I.—RAINFALL OF PRECEDING SEVEN DAYS, COMPARED WITH DEPTH OF WATER IN THE WELL—*continued.*

Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.	Week ending	Rain-fall.	Depth in Well.
1899	in.	ft. in.	1900	in.	ft. in.	1901	in.	ft. in.	1902	in.	ft. in.
Jan. 6	·54	30 0	Jan. 5	1·52	19 6	Jan. 4	3·06	57 1	Jan. 3	2·04	27 2
13	1·35	31 8	12	1·10	19 2	11	·43	35 4	10	·28	29 4
20	1·27	42 11	19	·70	24 3	18	·23	27 2	17	·02	27 2
27	1·19	42 0	26	·58	26 2	25	·36	27 3	24	·04	21 8
Feb. 3	·13	30 7	Feb. 2	·17	25 10	Feb. 1	·38	25 4	31	·72	18 1
10	1·98	38 11	9	·38	23 2	8	·52	21 7	Feb. 7	·06	17 2
17	1·40	46 9	16	1·58	28 10	15	·02	21 1	14	·10	16 4
24	...	35 11	23	2·20	36 2	22	·05	20 2	21	·01	13 5
Mar. 3	...	...	Mar. 2	1·55	36 9	Mar. 1	·45	19 2	28	1·08	13 11
10	·30	...	9	...	34 10	8	1·61	24 1	Mar. 7	·42	19 2
17	...	...	16	·24	26 9	15	...	27 5	14	·05	19 9
24	·04	...	23	·67	25 8	22	·24	21 7	21	·88	19 6
31	·27	...	30	·12	21 0	29	·07	19 5	28	·65	19 1
Apr. 7	·45	9 11	Apr. 6	·50	22 9	Apr. 5	1·27	21 7	Apr. 4	·19	19 2
14	·54	11 8	13	·25	21 4	12	1·64	29 4	11	·23	17 2
21	·39	10 1	20	·10	19 5	19	·63	30 1	18	1·33	20 4
28	·38	11 2	27	·11	15 11	26	...	25 11	25	·43	20 9
May 5	·12	9 11	May 4	·35	17 4?	May 3	·02	23 4	May 2	·16	18 10
12	...	8 3	11	·71	15 2	10	·82	19 5	9	·27	17 1
19	1·26	10 1	18	·50	13 2	17	...	17 1	16	·23	14 4
26	1·13	8 11	25	·85	12 6	24	...	13 5	23	·46	13 6
June 2	...	8 9	June 1	...	12 6?	31	·55	13 1	30	·48	12 5
9	...	8 6	8	·37	10 7	June 7	·16	12 11	June 6	1·05	11 5
16	...	8 5	15	·62	10 1	14	·12	12 4	13	·57	10 4
23	1·00	9 0	22	·43	8 6	21	·54	10 7	20	1·74	11 2
30	·30	7 10	29	·64	8 3	28	·21	9 6	27	·02	13 4
July 7	·89	8 6	July 6	·50	8 3	July 5	1·62	9 1	July 4	·18	12 6
14	·27	7 3	13	...	7 5	12	...	8 1	11	·32	11 2
21	...	6 8	20	·04	6 7	19	·50	7 2	18	...	9 10
28	·55	6 2	27	·14	6 3	26	·74	8 9?	25	·09	8 11
Aug. 4	...	5 5	Aug. 3	1·29	5 3	Aug. 2	1·17	6 2	Aug. 1	·61	7 4
11	·44	5 3	10	1·87	5 2	9	·09	6 1	8	·81	7 6
18	·30	4 6	17	...	5 3	16	1·26	6 1	15	·90	7 10
25	...	3 6	24	1·57	5 4	23	...	6 0	22	·92	6 4
Sept. 1	·94	3 9	31	...	5 2	30	1·02	6 3	29	·46	5 9
8	1·71	4 6	Sept. 7	·01	5 6	Sept. 6	·18	5 0	Sept. 5	1·21	5 2
15	...	3 6	14	...	5 4	13	·97	4 6	12	1·24	5 4
22	·37	3 0	21	·02	4 10?	20	1·01	4 6	19	·20	4 9
29	·28	2 11	28	·25	4 4	27	·73	4 2	26	·15	4 4
Oct. 6	1·37	2 6	Oct. 5	·71	4 3	Oct. 4	·76	4 2	Oct. 3	...	4 1
13	·20	1 8	12	·38	4 2	11	·42	4 0	10	·91	4 0
20	...	1 8	19	·36	3 3	18	·36	2 10	17	·62	3 11
27	·41	1 6	26	·43	2 10	25	·51	2 8	24	·59	3 9
Nov. 3	1·75	1 0	Nov. 2	1·64	1 6	Nov. 1	·08	2 6	31	·26	4 2
10	2·60	9 10	9	·85	4 3	8	·03	2 3	Nov. 7	·33	4 1
17	·11	11 6	16	·79	5 6	15	·75	1 9	14	·89	5 9
24	·05	13 9	23	·06	6 2	22	·13	2 4	21	...	7 8
Dec. 1	...	12 6	30	1·02	8 6	29	·10	1 8	28	·79	7 11
8	·81	11 5	Dec. 7	·97	16 8	Dec. 6	·09	1 6	Dec. 5	·92	11 7
15	·51	10 6	14	·45	21 4	13	2·32	2 6	12	·03	16 9
22	·03	10 2	21	·83	21 5	20	·18	15 11	19	1·61	24 6
29	·76	9 6	28	1·10	26 3	27	1·00	20 9	26	...	23 11

which overweight the more ordinary low levels in the remainder. The irregularities in this curve seem to show that 16 years are too few to give the real average of each week.

The next more noticeable point is that the height of the winter maximum bears no relation to that of the autumn minimum, the latter being, as a rule, more controlled by droughty or rainy periods later on in the season. It is a most curious coincidence that the year 1891, which started with a lower January depth than any other, should be the year in which the well was fullest throughout the summer, whereas 1901, which started January with the highest recorded depth, shows almost the lowest summer, and certainly the lowest autumn, level of the series. But 1901 was not only a dry summer but also one of excessive heat and evaporation, and the autumnal rains were almost absent.

A third very important point which the charts show well, is how very quickly, and to what a great extent, rains in the winter months raise the level of the water, and how little effect summer rains have. Apparently, when the soil once gets really dry, ordinary summer rains cannot penetrate, and even the autumn rains take a long time to do so.

Observe, too, how quickly the water subsides from these high levels. I think this is significant. We often hear it said that "we are so many inches short of our average," thereby implying that if those inches fell we should not have short supplies, but judging from these charts we have as much water as we want every winter. The ground is saturated, and what more can it hold? When more falls it runs away into the brooks and streams as fast as it can, hence this sharp fall of water-level from high points.

There was great scarcity in 1901, very little want in 1902; yet there was 1½ in. less rain in the latter year, of which previous winter showed the lowest maximum depth of the series, whereas, as we have seen, the winter 1900-1901 shows the highest. The prevalent notion that unless we get heavy rains in winter we shall be short in summer is, according to my figures, wrong. As I have just said, enough to thoroughly saturate the ground in winter is all that is required to fill the well. To keep up the supply in summer rainy periods later on are necessary, and it is when we miss them, and have great heat and dryness, that scarcity is likely to arise

It is instructive to compare the first half of 1901 with that of 1902. In the former the water-level fell from 57 ft. on January 1, to 9½ ft. by the end of June; in the latter from 29½ ft. on January 10, to 13½ ft. at June end. Yet there was 1¼ in. less rain in the second half year than in the first. 1901 was characterised by short, stunted crops and deficient herbage, 1902 by luxuriant growth of all ground vegetation. The reason is that in 1901 the rain fell in short periods with dry intervals, and temperature was high, whereas in 1902 the rain, though less in quantity, was more constant, and temperature being low there was less evaporation.

We will now briefly review the chief characteristics of each year.

1887.—The chart of this year is of a fairly normal type, though it was the driest year of the series, the total rainfall being only 21½ ins.; but there was no great scarcity, probably owing to a cold March, April, and May, so that the height of the water-level on June 24 was 13 ft., only

2 ft. lower than that of March 18. This was perhaps fortunate, as June, July, and August were hot and dry. Note the different effect of 1·15 in. in the week ending April 29, compared with that of 1·18 in. for September 9. At the time the former fell the soil was still moist and allowed percolation; the latter hardly penetrated at all, although the previous week had a fall of nearly 1 in. Most of the 2·7 ins. of the first week in November were evidently required to fully moisten the soil, since this great amount produced an almost insignificant rise for the time of year. Once the soil became moist, however, we find that moderate rains later on promptly produce their effect on the well. Notice, too, the curious rapid drop in the level on October 28, at the commencement of the autumn rains. This phenomenon occurs also in other years, *e.g.* 1893, 1898, 1899, 1900, and is also shown on April 28 of this year, but I am unable to suggest any explanation.

1888.—Frost and snow, during which the water-level sank 7 ft., held till March 7, when the thaw, accompanied by heavy rains, caused a rapid rise to 41 ft. on the 16th. From thence the water fell to 10 ft. on July 20; but that month being very wet and gloomy, with a total rainfall of 4¾ ins., the soil became moistened and allowed percolation, so that the level rose to 18 ft. 6 ins. on August 3, a very unusual circumstance. After this date it again fell, reaching its lowest point, 6 ft., on November 2.

1889.—Was very cold and wet till the end of May, so that June commenced with 26 ft. of water in the well, and the lowest point, 4 ft. 6 ins., was reached on October 25. Note what little effect the heavy rains in the weeks July 19, August 9 to 23, and September 27 had on the level.

1890.—Though this year had over 2 ins. more rain than 1887, the well showed a lower level throughout, probably owing to the marked absence of spring rains, so that the well started summer badly. However, a wet, windy July and showery August probably prevented what might have been a serious scarcity later on, as the autumn was remarkably dry. This, coupled with a frozen ground all December, was the cause of there being only 8½ ft. of water in the well at the end of December.

1891.—The frost held till January 19, when a thaw with good rains raised the level to 32 ft., and further moderate rains in March enabled it to be 22½ ft. at the end of that month, in spite of an absolute drought all February. The whole winter rainfall (October 1 to February 28) only amounted to 8 ins., *i.e.* 5½ ins. below the average of the 15 years, which would appear to forecast serious deficiency in summer; yet owing to this filling of the well in March, and the distribution of the heavy subsequent rainfall, the lowest reading during the summer was 8 ft. 3 ins., 8 ins. above the level of January 9.

Perhaps I may here be allowed to quote from a letter of the late Mr. G. J. Symons to the *Times*, dated March 3, 1891, in reference to this winter's drought. He ends his letter by saying: "I do not diverge into the effect of this drought upon the yield of springs and wells during the summer; the subject is too serious to be crowded into a letter already too long."

Had the late Mr. Symons the opportunity of seeing these charts, I do not think he would have said this; for what followed? The water-level only sank to 14 ft. by March 13, when that month's by no means heavy rains were quite sufficient to raise it to 23 ft.; this because the ground was still moist and allowed immediate percolation. April was

very dry, but the second half of May very wet, and the level rose by more than 5 ft. June was dry and warm. In July the amount of rain was large, but mostly in a few heavy falls; but August was extremely wet, no less than 6·12 ins. of rain falling, and the level rose from 8 ft. 3 ins. to 33 ft. on September 4. Such a rise in the middle of the summer has no parallel in the series. October again, with a rainfall of 8½ ins., was the wettest month since November 1852, and with the ground wet the level rose to 50 ft. on the 23rd of that month.

1892.—A dry March, April, and May brought the level down to 9 ft. by June 1; but as the following months were not hot, the level never sank below 3 ft. 2 ins. (on September 23), which is about the average minimum depth.

1893.—A "February fill-dyke" was followed by a long drought from March 1 till May 15; and the disastrous consequences of the absence of spring rains, and the absolute uselessness of most summer ones, are well shown here. The 1¼ in. which fell in the third week of May clearly did not reach the well, any more than the fairly heavy rains of July, although these were spread practically over the whole month. The level of water in the well pursues a remarkably regular course downwards from the very beginning of March till November. Most of August and September were very dry, so that good rains (3 ins.) in October (accompanied however by high temperature) were quite unable to penetrate. 6 ins. of water only in the well on November 15 (a mid-week sounding) is the lowest recorded.

1894.—This was a year of evenly distributed, heavy rainfall, no less than 37½ ins. being measured. Consequently the earth never really dried, and there was never less than 6 ft. of water in the well. One feature of the year was the very rapid rise on November 2, due to no less than over 4 ins. of rain falling between October 24 and November 2 on a soil that was moist. The rise of 27 ft. is, with one exception, the most recorded. Note that a very similar fall a fortnight later only raised the level, from its already high point, by some 15 ft. Seemingly the ground was so saturated that it could hold no more.

1895.—Although February was almost rainless, good rains about the end of March and end of April raised the level. Drought and heat during May and June, and till July 17, would doubtless have caused some scarcity later on, had not heavy rains in the last fortnight of July stopped the fall. Still 4 ft. 7 ins. was reached on November 1.

1896.—January and February were dry, March wet and windy, and it will be again seen that March is by no means too late to replenish underground supplies, as four weekly falls of less than ¾ in. each produce as decided an effect as an equivalent fall during the earlier months. It was then hot and dry till the latter part of August, and note how slowly the very heavy September rains influenced the well after such a long dry period.

1897.—Plentiful rains till the end of April kept the well full; then a dry (with the exception of isolated heavy falls) May, June, and July reduced the level to 8 ft. the end of the latter month. Although August was very wet, with a rainfall of 5½ ins., yet the well still sank, and did not rise till September 3, again showing what a quantity is required to thoroughly moisten the soil after such a long dry period, when evaporation is active too. Notice in comparison how even the relatively slight rains of the middle of October caused a small rise, the ground being fairly

damp, and how little the well sank during the next five almost rainless weeks, showing how little evaporation goes on in November.

1898.—The first three months were very dry, but constant rains at the end of April and during May raised the level somewhat, and had it not been for that wet period and a heavy fall on August 6 which managed to reach the well, there would have been great scarcity. As it was, there was only 1 ft. of water on October 14.

1899.—Although January and February were very wet, a long dry period followed, and the water never rose till November 10, its lowest level (1 ft.) being on November 3. There were 5½ ins. more rain this year than during 1898.

1900.—This was a very similar year to 1899. Starting from a low level, a wet January and February raised the level to 37 ft. by March 2. It then sank to 1 ft. 6 ins. by November 2, and had it not been for over 4 ins. of rain falling in August, it would probably have been lower. In view of the remarkably heavy rain (2¾ ins.) that fell on the single day December 30, a few daily readings of the depth of water were taken. The figures are as follows:—

1900.	Rainfall. ins.	Depth of Water in Well. ft. ins.	1901.	Rainfall. ins.	Depth of Water in Well. ft. ins.
Dec. 28	·11	26 3	Jan. 1	·01	54 7
29	·03	...	2	...	54 6
30	2·76	...	3	·02	58 10
31	·13	...	4	...	57 1

The rise of 31 ft. between December 28 and January 4 is the greatest change of level recorded in any one week.

1901.—Owing to the last-mentioned fall, the year 1901 commenced with the highest recorded depth of nearly 60 ft.; but in spite of this and of the unusual depth of 30 ft. in the middle of April, the scarcity of water in the late summer and autumn was almost more felt than in any other year. This appears to be more due to the absence of the usual October and November rains than to any great deficiency of them in the summer, or to any abnormal dearth of water in the well at that time. I append a few more frequent soundings which happened to be taken during the month of December, to show how the water rises at the period locally termed the "creating of the springs."

1901.	Rainfall. ins.	Depth of Water in Well. ft. ins.	1901.	Rainfall. ins.	Depth of Water in Well. ft. ins.
Dec. 1	...	...	Dec. 18	·02	...
2	...	...	19	...	...
3	...	...	20	...	15 10
4	...	...	21	...	...
5	·07	...	22	...	...
6	·01	1 6	23	·59	...
7	·62	...	24	·31	...
8	·14	...	25	·03	...
9	·15	1 9	26	...	...
10	...	1 9	27	·18	20 9
11	·22	1 9	28	·97	...
12	1·21	1 10	29	·32	...
13	·10	2 6	30	·08	...
14	·01	7 6	31	·14	...
15	·02	...	1902.		
16	·01	...	Jan. 1	·34	...
17	·03	...	2	·01	27 2

1902.—The last year of the series was uneventful and characterised by no extremes. As there was no great summer heat, and an unusually cold protracted spring, evaporation was probably less than usual, and the well never became very low. The rainfall, 26½ ins., or 1½ ins. less than in the previous year, was singularly evenly distributed. In connection with this year, I would quote the following extracts from the memorandum by the engineer on the flow of the river and rainfall in the Thames valley during 1902:—

"The flow of the river during 1902 was the lowest for the past 20 years. The rainfall in the Thames valley was 23·2 ins., or less by 3 ins. than the average rainfall for the last 20 years."

"I would call attention to the fact that, notwithstanding the deficiency of rainfall and the small proportion which reached the river, the flow during the summer months was both constant and plentiful."

I venture to think that my chart for 1902 almost explains this. It will be seen that there were no very high points reached, that is, no floods; the well was never very low, so the river was never very low. From his remarks on the small amount of rain reaching the river, the suggestion arises: Does not the level in the river depend more on the amount of storage water higher up its tributaries than on the rainfall of the Thames valley?

He goes on to say that the water companies abstracted during the year about 20 per cent of the water. This does not seem excessive, but when he further states that in the month of July no less than 147 out of a total of 353 million gallons were taken, approximately two-fifths, it seems to me that the limit has been more than reached, and that we ought in the future to look for other means for supplying London's great needs. And what better means can we find than by the storage of our surplus winter rains?

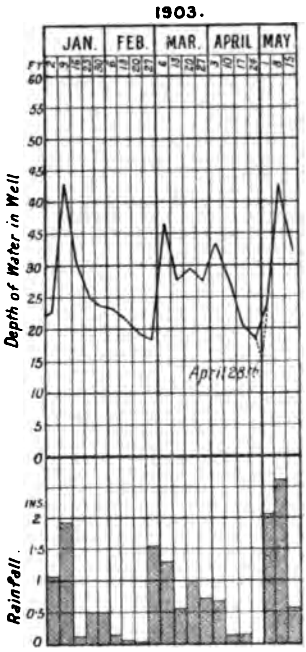

Fig. 1.

1903.—This year has proved very unusual so far. Till the end of February the five winter months' rainfall was rather more than half an inch *below* the average of the sixteen years, and at that date the well depth was 5 ft. below the average, so that, according to the usual ideas on the subject, some shortage was probable later on. Fortunately, March, with over 4 ins., filled the well, and the very heavy fortnight's rain at the end of April and beginning of this month (May) raised the level to the record height for that date of 42 ft. 7 ins. on the 8th; so that I think that it might be safely forecasted *now* that there will be no great scarcity in the district this year. But had March, April, and May been dry, there *would* have been scarcity whether the winter rains had been abundant or not. This is well borne out by 1899, in which year the previous winter's

rainfall was even heavier than last winter's, and which showed a well depth at the end of February nearly double that of this year.

I now proceed to summarise some of the figures, with a view to ascertaining how they bear out my arguments.

Table II. shows the total rainfall of each year, and the maximum and minimum depth of water in the well. A little consideration will show that the maximum and minimum in the year bear no relation to each other or to the year's total rainfall.

TABLE II.—Annual Rainfall with Maximum and Minimum Well Depth.

Year.	Rain-fall.	Max. and Date.		Autumn Min. and Date.		Year.	Rain-fall.	Max. and Date.		Autumn Min. and Date.	
	in.	ft. in.		ft. in.			in.	ft. in.		ft. in.	
1887	21·58	47 7	Jan. 21	2 11	Oct. 28	1895	28·97	44 9	Jan. 25	4 10	Oct. 4
1888	31·35	40 9	Mar. 16	5 11	Nov. 2	1896	25·65	27 9	Jan. 3	2 10	Sept. 4
1889	26·76	38 10	Mar. 15	4 6	Oct. 25	1897	34·27	42 4	Feb. 12	5 11	Aug. 27
1890	23·70	32 8	Feb. 7	2 0	Nov. 7	1898	23·30	34 10	Jan. 7	1 1	Oct. 14
1891	37·85	32 3	Feb. 6	8 3	Aug. 21	1899	28·81	46 9	Feb. 17	1 0	Nov. 3
1892	24·10	29 0	Jan. 1	3 3	Sept. 23	1900	33·81	36 9	Mar. 2	1 6	Nov. 2
1893	22·50	35 0	Feb. 24	0 8	Nov. 10	1901	28·06	57 1	Jan. 4	1 6	Dec. 6
1894	37·85	35 6	Mar. 16	6 5	Sept. 7	1902	26·53	29 4	Jan. 10	3 9	Oct. 24

Table III. gives the average depth of each of the first three months in comparison with the subsequent minima, and in Table IV. I have separated the years into groups of four in the case of January and February, and of five in March, taking the four highest together, and so

TABLE III.—The Average Heights of the Water in the Well, Compared with the Subsequent Minimum.

Year.	Jan.	Feb.	March.	Autumn Minimum.	Year.	Jan.	Feb.	March.	Autumn Minimum.
	ft. in.	ft. in.	ft. in.	ft. in.		ft. in.	ft. in.	ft. in.	ft. in.
1887	39 3	25 1	16 4	2 11	1895	31 5	24 3	17 10	4 7
1888	17 10	14 2	28 0	5 11	1896	22 0	15 3	18 9	2 10
1889	27 8	22 11	27 4	4 6	1897	30 10	34 1	33 6	5 11
1890	24 9	24 6	15 3	2 0	1898	26 6	15 7	14 1	1 1
1891	12 8	24 6	19 2	8 3	1899	36 9	38 0	...	1 0
1892	21 9	21 11	20 8	3 3	1900	22 3	28 6	29 0	1 6
1893	17 5	29 11	25 11	0 8	1901	36 8	22 0	22 4	1 6
1894	19 2	25 1	28 9	6 5	1902	24 8	15 2	19 4	3 9

on, and comparing these averages with those of the subsequent minima. These figures are very instructive. Both in January and February, if any relation is shown, it is exactly contrary to what would be expected. The four years showing lowest average depth in January are actually followed by an average minimum more than double as high as that which follows the average of the four highest Januaries; and in February, the four "fill-dykes" appear to be followed by droughts. But in March we begin to get a true relation, and as this appears to be a critical month, I have drawn up Table V., which shows the whole rainfall from October 1 to March 31 of each winter, compared with the

lowest depth to which the water-level in the well sank in the ensuing summer or autumn; and I think it will be seen that no relation exists

TABLE IV.—The Relation of Groups of Averages of the First Three Months to Subsequent Minima.

		Average of 4 Subsequent Minima.
January.	ft. in.	ft. in.
Average of 4 highest years	36 0	2 6
,, ,, next highest years	27 5	3 4
,, ,, ,, ,,	22 8	2 10
,, ,, lowest years	16 8	5 3
February.		
Average of 4 highest years	32 7	2 3
,, ,, next highest years	24 9	4 11
,, ,, ,, ,,	22 9	3 5
,, ,, lowest years	15 0	3 5
March.		
Average of 5 highest years	29 4	4 10
,, ,, next highest years	21 6	3 6
,, ,, lowest years	16 5	2 8

between the two. In fact, if we take the average rainfall (18·84 ins.) of the four wettest winters, and the average rainfall (11·29 ins.) of the four driest, and compare them with the subsequent average minima (2 ft. 7 ins. and 3 ft. 5 ins. respectively), we see that the latter is actually nearly 1 ft. higher than the former.

TABLE V.—The Winter Rainfall (October 1 to March 31) Compared with the Subsequent Minimum Well Depth.

Winter.	Total Rainfall.	Subsequent Minimum.	Winter.	Total Rainfall.	Subsequent Minimum.
	in.	ft. in.		in.	ft. in.
1886-1887	17·21	2 11	1894-1895	19·59	4 7
1887-1888	13·47	5 11	1895-1896	15·18	2 10
1888-1889	16·08	4 6	1896-1897	18·31	5 11
1889-1890	15·91	2 0	1897-1898	10·33	1 1
1890-1891	9·40	8 3	1898-1899	18·48	1 0
1891-1892	18·46	3 3	1899-1900	18·82	1 6
1892-1893	12·57	0 8	1900-1901	17·20	1 6
1893-1894	16·29	6 5	1901-1902	12·89	3 9

		Average subsequent minimum.
	in.	ft. in.
Four winters of highest rainfall average	18·84	2 7
,, next highest ,, ,,	17·25	4 2
,, ,, ,, ,,	15·16	3 10
,, lowest ,, ,,	11·29	3 5

My conclusions are briefly as follow:—

1. The depth of water in this well depends on how much rain penetrates.

2. The penetration is determined by the amount of rain, the rapidity of its fall, and the existing condition of the soil.

3. The condition of the soil depends on the frequency of the falls of rain and the amount of evaporation.

4. Therefore winter rains penetrate easily, summer rains with difficulty; but summer rains, especially when accompanied by lessened evaporation, tend to moisten the soil, and the water-level does not fall so rapidly.

5. Evaporation has but little effect till April or May; but thence till the end of September almost as much, and sometimes more, moisture is lost from that cause than falls as rain.

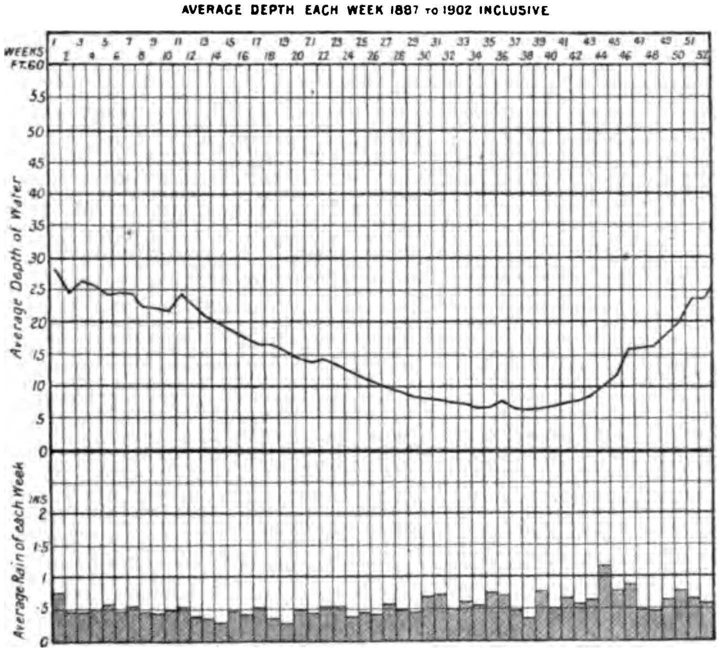

FIG. 2.

6. The effect of even prolonged rainy periods is of a far more temporary character than is generally supposed, so that, however heavy the winter rains are, and however full the well is then, it by no means follows that there will not be scarcity in the summer or autumn; but should the well be full in March, and better still in April or May, want is not probable.

7. The well is every winter filled sufficiently, and no amount of extra rain then will make it hold out longer; therefore scarcity in summer or autumn depends on what happens later, and especially in the spring months.

8. Mere absence of rain is not the only cause of scarcity, deficiency of spring rains and subsequent heat and evaporation being far more important factors.

9. After the early spring months, but little rain usually penetrates to the well, so that a timely forewarning at that season might prove of

great value by enabling the existing supplies to be husbanded at an early period.

10. Considering how narrow the boundary is between sufficiency and want, and looking to the fact that every year sees further demands made on our water supplies, it is of the utmost importance that more attention should be paid to the storage of our surplus winter rains. This might be done by the formation of large hill reservoirs and reservoirs along the course of rivers as proposed by Col. Bolland (*Times*, April 13, 1903), and doubtless such measures as the re-afforesting of large tracts of land would be of use in checking the rapidity with which the rains reach the rivers, and are so lost.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) thanked Dr. Hooker for his valuable and interesting paper, which ought to be of practical use in fixing attention on a matter requiring investigation. Dr. Hooker pointed out that country districts are being drained of their water, which goes to supply the towns, and advocates the storage of surplus water. It seemed to him (Capt. Wilson-Barker) that nothing is done in towns to conserve the water, in spite of the fact that the artificially prepared roads from their nature offer special facilities for the collection of water, which could afterwards be purified. It would be interesting to hear this paper freely discussed, it is one which brings us in touch with geological considerations.

Admiral J. P. MACLEAR said that for the last three years he had been observing two wells in the hope of obtaining a relation to the rainfall, and his results were similar to those shown in Dr. Hooker's paper. One of these wells was 44 ft. deep, with a rise and fall of 22 ft. ; the other was 16 ft. deep, with a rise and fall of 8 ft. There were two or three other conditions which influenced percolation : one was the saturation of the earth by continuous falls of rain. A few years back, in November, when the Thames valley floods were out, the ground had become so saturated that it could hold no more, and he had seen the water pouring down off the surface of slightly sloping fields as though off the tiles of a house. Again frost. Of late winters we had generally had frost before snow ; when this is the case, the ground being hard, the moisture evaporates and none goes into the well, but in the opposite case of snow coming before frost, the moisture percolates to the well. Pressure also had some effect upon the rise and fall of the water. He would like to know whether the well at Further Barton was lined or not, and of what diameter it was.

Mr. B. LATHAM stated that the well from which the records alluded to in Dr. Hooker's paper were taken was one which he had discovered had been measured many years ago by the late Mr. T. C. Brown, and the records from 1866 to 1868 were published in the *Report of the Royal Commission on Water-Supply* (Duke of Richmond's Commission). He had been furnished with the measurements of this well from time to time now for some years past, and he observed that the well was one of those which were extremely sensitive to the effects of rain. Located as it is on the Oolitic formation, wells in this particular geological strata are very much more sensitive than wells in the Chalk or New Red Sandstone. It should be borne in mind that all underground water is constantly on the move, and that it is always flowing away in some particular direction, and that the fluctuations in the water line in the course of time indicate the position of a well in the drainage area, for if a well was located close to the

point at which the springs broke out the rate of the fluctuation in the water is very small in the course of a year, often only measured by a few inches in depth, whereas a well distant from the point of outfall in a considerable drainage area might have a fluctuation in the water line of over 100 ft. in the course of a single season. During the past year the water in this well, as in other wells, has been comparatively low, but not so low as in the year 1893. The water in this well has been found to follow the rainfall to a very great extent, that is, the average depth of water in the well during the course of the year is found to follow almost in parallel lines the actual depth of rain falling. Of course evaporation to a very considerable extent influences the amount of rain percolating, and in the summer months of the year, when evaporation is very active, of course it is almost impossible for any replenishment of the wells to take place. The amount of evaporation taking place from an earth surface has been shown by the difference of actual rainfall and flow off the ground, and does not differ from the actual evaporation which takes place from a water surface. On the other hand, it must not be lost sight of that a certain amount of condensation takes place in the ground especially in warm weather when the external air is warmer than the soil. The reference to the Thames water-supply is not such an important point as it would appear to be, as the figures show that even in the lowest period, when 147 million gallons a day were taken out of 353 million gallons present in the Thames, it did not indicate any liability to running short of water in such a dry year as last year. The only water required in the Thames was really for the purpose of lockage, as the moment we get into the tidal portion of the Thames there is the well-known law, that the moment the upland water begins to diminish the tidal water begins to increase, so that if there was absolutely no water coming down the Thames its tidal channel would be filled every tide with tidal water. He was sure they were all very much indebted to Dr. Hooker for his clear and concise tabulation of the fluctuations which had occurred in this well compared with the local rainfall, and he thought that the great value of the paper would be hereafter fully recognised.

Colonel T. English thought the paper most valuable, but would suggest one point for further information. It was known that a well could only be supplied by the water which pours into it from springs, etc. but there seemed hardly enough particulars given to correlate with the levels of other wells. The height was mentioned, and the position of the well as being two miles from Thames Head, but this was not enough to show whether the water was flowing towards Thames Head or in other directions.

Dr. H. R. Mill remarked that he was mainly interested in the fluctuations of rainfall before it entered the ground ; it was interesting to see how the water level as indicated by wells was affected by rain. The weekly records were extremely valuable, and showed a certain relationship to rainfall, but daily measurements were wanted in order to show exactly what the relations were. The last year, 1902, had been a remarkably dry one—possibly the driest since 1887, and yet the wells had not run dry. The explanation suggested for this was that the periods at which rain fell, and the rate of fall rather than the absolute quantity, was what affected the fluctuation of wells. The action of frost upon the ground must have several effects. For one thing, when the ground is sealed up by frost so as to prevent air from entering, the water cannot percolate out of the rock, however pervious, into the wells, which should therefore at such times remain level. The thanks of the Fellows were due to Dr. Hooker for his interesting paper, and the clear manner in which his figures were set forth. The paper was one of those desirable contributions the value of which would be appreciated as much in after years as now.

Mr. C. Beadle observed that what seemed to add very much to the value

of Dr. Hooker's paper, was that it came to conclusions precisely the same as those arrived at by investigations made by others with percolation gauges. It was the first time such conclusions had been arrived at by means of well measurements. Dr. Hooker did not appear to be aware of the existence of measurements exceeding 3 ft., but the Lawes and Gilbert measurements taken at Rothamsted extended to depths of 40, 50, and 60 ins. The 60 ins. measurement showed a falling off in the amount of percolation, though he (Mr. Beadle) did not know to what depth the falling off extended, as a consequence of the evaporation through the earth.* With regard to the effects of vegetation on evaporation there were some valuable records in 1876 as to differences induced in ordinary soil and in turf. These results showed that the percolation through turf was far less than percolation through ordinary soil, in consequence of the evaporation being increased through vegetation. The difference between the two was greatest in June (53 per cent), and least in January (under 10 per cent).

Mr. J. HOPKINSON said that Dr. Hooker had mentioned the Rothamsted records of percolation as the only published ones known to him bearing on this subject, but there were others more closely related to it than those. In vol. i. of Symons's *Meteorological Magazine* were records of the depth of water in wells at Chilgrove near Chichester and Hartlip near Sittingbourne compared with the rainfall; and in vols. v. and vi. of the *Transactions of the Hertfordshire Natural History Society* were records of the depth of water in deep chalk wells at Barley and Odsey, both near Royston, at the first named place for 23 years, the depth on the 1st of each month being compared with the rainfall of the previous month. These Hertfordshire experiments showed that there was generally a rise for the five months November to March, and a fall for the remaining months of the year. The percolation in a Chalk district was different from that in Oolitic rocks, owing to the large amount of water which chalk will absorb and retain, but it was well known that in both a long steady rainfall was of more benefit to the underground water-supplies than occasional heavy falls. A series of experiments on percolation had been made for many years at Nash Mills, Hemel Hempstead, the record for the 42 years 1842-1884 (April to March) giving a summer percolation (April to September) of 10 per cent of that of the year, and a winter percolation of 90 per cent. Similar experiments at Lea Bridge for the 21 years 1852 to 1873, gave a summer percolation of 12 per cent of that of the year, and a winter percolation of 88 per cent. This, in both cases, was through 3 ft. of the ordinary soil of the district with grass growing on the surface. The Rothamsted experiments gave the percolation through various depths of soil purposely kept free from vegetation, and through 5 ft. for the 31 years 1871 to 1902 (April to March) the summer percolation was 26 per cent of that of the year, and the winter percolation was 74 per cent. The annual percolation in relation to the rainfall was 24 per cent at Nash Mills, and 26 per cent at Lea Bridge, while at Rothamsted it was 48 per cent, showing that with vegetation not only is there very much less percolation than there is without it, but that there is also, as might be expected, a much greater difference between that in the summer and that in the winter. In fact, it might be said that in a Chalk district a quarter of the rain which falls percolates on the average at least 3 ft. down if grass is growing on the surface, and half if the surface is kept absolutely free from vegetation of any kind, showing that growing vegetation absorbs about a quarter of the rainfall. The decrease in the available water-supply in permeable areas, owing to the abstraction of large quantities of water from great depths lowering the water-level, was a matter of great importance. For many years, up to about the year 1875, the average daily flow of the Chadwell spring near Ware was 3,600,000 gallons, but for the last three years its average

flow had been less than a quarter of that amount, and for the year 1901-2 (July to June) it was only 7 per cent, or one-fourteenth, of the average maintained up to the year 1875. But the case was really worse than this, for during the summer months, since the spring first failed in the summer of 1898, the river Lea had to be prevented from flowing into its basin, otherwise the channels of the spring would probably have absorbed more water in the summer and autumn than they gave out in the winter and spring, so that the spring, which in the reign of James I. was considered to be sufficiently ample and permanent to supply the whole of London with water, had now practically ceased to flow. This was the result of the lowering of the water level in the Chalk, by the abstraction of large and increasing quantities of water from the deep wells of the New River and East London Water Companies. The Chadwell spring, when flowing, sometimes took two or three months to fully respond to the rainfall; the Further Barton well seemed usually to respond by the close of the following week, but sometimes, as in 1887 between November 4 and December 2, not for a month. Although Dr. Hooker's paper was not the first on the subject, he believed that it was the first which gave weekly instead of only monthly records, and he considered that its great value was in the facility which it gave of comparison between the rainfall and the height of the water in short periods of time.

Mr. R. H. Hooker said that he should like to make a few remarks on the question of the use of water-works catchment areas by corporations. Forests tended to conserve the water that fell by preventing both excessive evaporation and floods. It would be worth the corporations' while to contribute towards this by more planting, and such forests, if properly managed, would pay a moderate interest. Liverpool seemed to have taken the lead in this respect. He thought corporations might do a great deal of good in this matter, and at the same time obtain interest for their outlay on land which is now practically unused. He was acquainted with Mr. Hopkinson's earlier papers, but no reference had been made to them because they did not touch the point of the present paper, viz. a consideration of the weekly measurements, and Mr. Hopkinson's monthly measurements did not throw any light on the particular point investigated. The annual average rainfall and average depth of the well might certainly coincide, but that did not necessarily prevent drought in autumn. The point was to find how the rain percolated to the well. The author had mentioned that this well differed from others in its extreme sensitiveness, but, however exceptional it might be, he desired to emphasise its great importance, inasmuch as it plunges into an underground sponge whence the Thames itself derives its supply. Mr. Latham had suggested that Nature's laws and tidal waters were all that was necessary to keep up the supply for navigation purposes; why then had it been necessary to construct a lock below Richmond a few years ago?

Dr. C. P. Hooker, in reply, stated that the well mouth was about 4 ft. in diameter, and he understood it was not lined. It was difficult to criticise Mr. Latham's remarks, as he had not had the advantage of seeing them on paper beforehand, whereas Mr. Latham had seen the whole of his paper. He took exception, however, to the view of trusting too much to Nature in the matter of water-supply. The Thames fulfilled other purposes besides that of being a drinking fountain for London, and navigation, fishing, and sanitary requirements ought not to be forgotten. There was no question as to the diminution of its stream, and even in the neighbourhood of Cirencester he knew of two trout streams, one of which had entirely disappeared, and the other had virtually done so. The position of the well in question was on a slight plateau, and he had no doubt the flow of the underground water was towards Thames Head. The Thames required a large supply of water, and he believed a great proportion of

it came from the Cotswold Hills, beneath which water was commonly found at a depth of about 80 ft., a fact which seemed well known to the "water diviners." The records of this well previous to 1837 were only in the form of monthly averages, which were valueless for his purpose. He would have liked to secure a daily record of the well in winter, as its fluctuations were great and frequent, and it was as sensitive as a barometer. The subject of the difference in the evaporation from turf and soil was most interesting; the more finely divided the surface soil was the less was the evaporation, which was why gardeners hoed in hot, dry weather instead of using the watering pot.

Climate of Peru.—We have received from Mr. E. Higginson, the Consul of Peru at Southampton, a *Map of the Republic of Perú*, with a short description of the country, its geographical features, climate, etc. The following information about the climate will no doubt be of interest:—

Peru being situated in the Torrid Zone, it might be inferred that the climate would be warm throughout the country; but, owing to the great differences of elevation and its rugged surface, it enjoys every variety of climate, and a settler may suit his taste to a nicety in choosing his location, whether his intention be to engage in agriculture, in manufacture, or in mining.

Notwithstanding its tropical position, the country is healthy, and free from those dangerous diseases which generally prevail in the Torrid Zone.

Along the coast the mean temperature is from 64° to 68°. Those who desire cooler, or even cold weather, have but to ascend the roads from the coast leading towards the Andes mountains; the heat of course diminishes gradually as the higher altitudes are reached.

On the Sierra it is as cool as in the South of England; on the Coast it is as warm as in the South of France, and is not very much warmer on the Montaña; while on the Punas it is as cold as in Scotland.

A fair idea of the mean temperature in each of the three zones of Peru may be gathered from the following figures:—

Coast.	°	*Sierra.*	°	*Montaña.*	°
Peura	77	Cajamarea	52	Iquitos	75
Lima	66	Huaraz	59	Haiánues	74
Moquegua	63	Arequipa	57	Santa Ana	72

The region of the *Coast* is sunny, and rain seldom falls. At Lima, and all along the coast, the sun is tempered by the cool Southerly breezes, and the climate throughout the year is well suited to Europeans. The sun is rarely hidden by clouds for a single day in the year. The maximum temperature at Lima in the summer is 78°, and in the winter 59°.

The *Sierra* is subject to rain and snow in winter.

In the *Montaña* there are two seasons: the dry, which lasts from May to October; and the wet, from November to April. The total annual rainfall is estimated at about 70 ins., but being at a considerable elevation, no part can be called unhealthy.

THE FROST OF APRIL 1903.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read May 20, 1903.]

THE weather from January 19 to March 31 was very mild, the mean temperature at Greenwich for this period of 72 days being 45°·2, which was 5°·7 above the average. Normal or cooler weather prevailed during the first 11 days of April, but on the 12th (Easter Sunday) an abrupt change took place which continued until the 27th. During this time low temperatures prevailed, accompanied by keen Northerly winds and great dryness.

The fortnight, April 12 to 25, was so distinctly marked by these characteristics that it seems desirable to inquire into their distribution.

The main features are shown by the values for the Royal Observatory, Greenwich, in Table I.

TABLE I.

1903.	Jan. 19 to Mar. 31.	Diff. from Average.	April.	Diff. from Average.	April 12-25.	Diff. from Average.
	°	°	°	°	°	°
Temperature—Mean	45·2	+5·7	44·1	−3·1	40·8	−6·9
Do. Mean Max.	51·2	...	52·0	−5·4	49·6	...
Do. Mean Min.	39·2	...	36·7	−2·0	32·5	...
Dew Point	38·9	...	35·2	−5·0	29·5	−10·7
Relative Humidity	79	−5	71	−7	64	−14

There were 13 days during April on which the maximum temperature was below 50°. This number has only been exceeded on one occasion during the past 54 years, viz. in 1888, when there were 15 days below 50°, 4 of which were below 45°.

There were 14 days during the month on which the minimum temperature was below 35°, 7 of which were below 32°. This number has been equalled or exceeded on three occasions, viz. in 1852, with 19 days, and in 1879 and 1892, each with 14 days below 35°.

There were 14 days during the month on which the mean relative humidity was below 70 per cent, 10 of which were below 65 per cent. Nine of these occurred between the 12th and 25th. The lowest values were 57 per cent on the 18th and 56 per cent on the 25th. There have only been two other instances in the month of April with as many days with such low relative humidities. These were 1892 with 10 days, and 1893 with 12 days below 65 per cent. There have, however, been lower relative humidities recorded on individual days, the absolute lowest being 44 per cent on April 20, 1870.

The above features are typical of what occurred generally over other parts of the country, as will be seen in Table II. from the following results for the month of April 1903 at a few of the stations of the Royal Meteorological Society :—

TABLE II.

Stations.	Lowest Temperature.		No. of Frosts.		
			In Air.		On Grass.
	In Air.	On Grass.	Month.	12-25.	Month.
	°	°			
Rothbury	25·4	...	12	11	...
Hillington	29·5	24·1	8	7	18
Lowestoft	28·3	25·5	7	7	10
Bennington	27·2	20·9	10	10	22
Hodsock	22·7	12·8	13	11	23
Churchstoke	25·6	14·2	12	11	22
Ross	25·6	21·5	10	9	15
Norwood	28·0	22·7	8	8	20
Marlborough	22·8	18·7	12	11	20
Margate	33·0	29·1	0	0	3
Worthing	28·4	24·4	6	6	13
Bournemouth	28·5	22·5	6	6	18
Bolton	27·3	22·9	9	9	16
Southport	27·2	12·2	6	6	15
Hoylake	28·7	19·0	3	3	13
Llanbedr	30·0	...	6	6	...
Rumney	29·0	...	6	6	...
Bath	27·0	16·0	8	7	18
Whitchurch	27·3	20·6	5	5	17
Salcombe	31·0	...	3	3	...
Falmouth	31·0	...	1	1	...
Penzance	34·7	...	0	0	...

Taking England and Wales as a whole there were 10 nights during the month on which the temperature fell to 32° or below, 9 of which were between the 12th and 25th. The greatest number was 14 at Appleby, with 12 between the 12th and 25th. The only stations at which the temperature did not fall to 32° were Margate, Ilfracombe, Woolacombe, and Penzance.

The number of frosts on the grass was very great, there being as many as 23 during the month at Hodsock, and 22 at Bennington and Churchstoke.

Snow and hail showers were frequent between the 12th and 17th, especially in the north-east and east of the country. The snow was general all over most parts of the Continent, and was so heavy in Denmark and Russia as to stop railway traffic.

The whole of the British Isles came under the influence of this cold spell; and it is remarkable how uniformly the low temperatures were distributed. This will be readily seen from Table III. compiled from the *Weekly Weather Report.*

One of the special features of this period was the great radiation, the minimum temperature on the grass at several stations being 12° below that in the air, while at Southport the great difference of 16° was recorded on the 17th. This great radiation, as will be seen from Table III., is borne out by the amounts of sunshine which were in excess of the average, and especially so in the north-west and midland counties. It was due to the great dryness of the air, and also to the distribution of atmospheric pressure, which was peculiarly favourable for radiation.

It will, perhaps, be best to quote the following remarks on the distribution of atmospheric pressure from the *Weekly Weather Report*:—

TABLE III.—BRITISH ISLES, APRIL 12-25, 1903.

Districts.	Temperature.		Sunshine.
	Lowest observed.	Mean below Average.	Difference from Average.
	°	°	hrs.
Scotland N. . . .	24	-6	+11
„ E. . . .	23	-7	+18
„ W. . . .	24	-7	+14
England N.E. . .	24	-6	+25
„ E. . . .	24	-7	+21
„ Mid. . .	25	-7	+36
„ S. . . .	24	-6	+17
„ N.W. . .	24	-7	+43
„ S.W. . .	25	-6	+20
Ireland N. . . .	26	-6	- 6
„ S. . . .	25	-6	+ 3

Week ending April 18.—"The distribution of barometric pressure during this period underwent several minor modifications, but the chief permanent features were,—an anticyclone off our south-west or west coasts, which, during the latter days, spread gradually over nearly the whole of our islands, and low-pressure areas, or definite cyclonic disturbances, which moved or spread south-eastwards over Scandinavia and its neighbourhood, and depressions of various size and depth over the Mediterranean. The North-westerly and Northerly current of wind in the rear of the northern disturbances, and especially in the rear of a small system which travelled quickly south-eastwards across our islands on Tuesday night, was very keen, and reduced the temperature over the United Kingdom and the neighbouring portions of the Continent to many degrees below the normal, so that sharp frosts were experienced almost every night, and the daily maxima were very low. The Mediterranean depressions were mostly shallow and ill-defined, but towards the end of the week a very deep system was developed over the Gulf of Genoa, giving rise to violent gales in that region, and to heavy rains over Italy and the Adriatic. Our islands and the northern countries generally were visited by frequent showers or steady falls of snow or hail, but they were usually heavier on the Continent than in this country. At the end of the period a depression of considerable size and of increasing energy was moving north-westwards across central Europe, and causing strong winds or gales over Germany, Austria-Hungary, and the adjacent parts of Russia, accompanied by very heavy falls of snow."

Week ending April 25.—"The general level of the barometer over Europe during this period was low. There were only two principal cyclonic systems, but these were both large and rather deep. The first, whose centre lay over East Prussia on Sunday (the 19th) embraced the major portion of the Continent. It subsequently travelled slowly northwards to Scandinavia and the Gulf of Bothnia, where it dispersed about the middle of the week. This system brought exceedingly rough weather throughout the more central parts of the Continent and over the Baltic, strong winds or gales and very heavy falls of snow or rain being experienced generally. The second low-pressure system reached the north-west of France from the Atlantic by the morning of Wednesday (the 22nd), whence it moved eastwards to Baden, northwards to Bremen (by which time its gradients had become steep, owing to a baric rise in the surrounding regions), and subsequently westwards to the north of Holland,

in which position it gradually dispersed. This system also caused strong winds in the various countries under its influence, and unusually heavy and persistent rains over France, Germany, and the Netherlands, while one of its southern secondaries occasioned an inch or more in different parts of Italy. These depressions only brought comparatively slight and local falls of snow or graupel to our islands, but on Saturday (the 25th) a large, irregularly shaped disturbance was advancing over us from the westward, and by night rain had set in very generally over our western and southern districts. Temperature was again low for the time of the year, and nocturnal frosts very common over all except the southern countries. During the night of the 19th-20th the sheltered thermometer recorded a reading of 31°, even as far south as Florence."

Owing to the great mildness of the weather during February and March vegetation was in a very forward condition, and as a consequence suffered very severely from the frost. The extent of the damage will be gathered from the following reports by *The Times* agricultural correspondent, by Mr. H. Southall, and by Mr. E. Mawley :—

"The mischief wrought by the frosts at Eastertide, especially to fruit-trees, has now become more apparent, and the loss, unfortunately, will be greater than it seemed safe to suggest a week ago. Such rosaceous fruit-trees, as the pear, plum, and cherry, are not scattering their petals, like flakes of snow, as they do in a normal season, and there is upon the ground no white litter to become the sport of the winds. The reason is not far to seek, for examination shows that the petals were frozen to death on the flowers, where their withered remains impart to the trees a brownish unnatural hue. A frost that kills the petals is severe enough to kill the pistil, which it is the function of the petals to protect, and as the pistil is the early stage of the fruit, the extensive failure this year of stone-fruit in particular is unhappily already assured. Apple-trees have, in many cases, remained as they were a fortnight ago, with the flowers fully exposed but not opened."—*The Times*, April 27.

"The evil that frosts do lives after them, and the ill effects of the arctic period that set in a month ago are more plainly visible now than they were then. Leaves brown and withered upon the lilac and horse-chestnut, blackened young shoots upon the hardy ivy, and the leaves of raspberry canes and gooseberry bushes killed here and there, tell of a severity of frost that was more than sufficient to destroy the young fruit in its tenderest and most susceptible stage. Plants weakened thus more easily fall a prey to other foes, and the appearance of aphis upon the plum-trees, of the caterpillars, of the brown-tail and other moths upon pear-trees, and of the disgusting and defoliating larva of the sawfly upon gooseberry branches, are present examples of the fact, as is also the paucity of the bloom—which a month ago promised to be so wealthy—upon the roadside hawthorn."—*The Times*, May 11.

"I do not remember a similar year in season to the present. On April 11th we were exceptionally forward as regards vegetation. A typical plant which serves as a good criterion for time of year (the blackthorn) came into flower on March 13th, and that is quite the earliest I have noticed it doing so. I have known it as late as April 20th. The gardens were quite gay—fruit-trees, crown imperials, magnolias, and lilacs, etc. in first blossom—and we were vainly imagining that the winter was past and gone. The succession of severe frosts and biting winds (April 12 to 25) every night except 15th and 21st, with much sun by day, giving a range of 36° in 24 hours, soon "told a tale," and now Magnolia Sinlangeana, a large tree with some 500 blossoms, instead of being a magnificent sight with its large flesh-coloured blossoms, is blackened and disfigured all over.

"The injury is not confined to what we consider the more tender plants, many of which were not sufficiently developed to be much injured, nor was it merely due to *ground* radiation. I have never known such an effect produced before. On the other hand, some plants, although dwarf growing, are scarcely injured at all. Some will doubtless spring up again from the roots, but I fear most of the fruit crop is utterly gone."—HY. SOUTHALL, Ross, May 11.

"It is impossible as yet to estimate at its true extent the injuries done by the April frosts and cold winds to the fruit crops. As far as I am able to judge from the reports sent in to the gardening papers, the destruction of the fruit blossom, taking the country as a whole, has been very great and also very general. Peaches, apricots, plums, cherries, pears, gooseberries, currants, and raspberries, appear to have all suffered more or less severely. In many places a good deal of the apple and strawberry blossom, although only in bud at the time, was killed, while potatoes were cut to the ground, and the foliage of horse chestnuts and limes much injured, particularly on the windward side."—EDWARD MAWLEY, May 15.

DISCUSSION

THE PRESIDENT (Capt. D. WILSON-BARKER) said that special thanks were due to Mr. Marriott for this paper which, at the request of the Council, he prepared on very short notice. It is important that such occurrences should be promptly investigated while the circumstances are still fresh in the memory. It is hard to say whether science will ever devise means to minimise the effects of the vagaries of our climate, but with advancing knowledge we may at least hope to learn how and when to anticipate sharp and sudden changes.

Mr. H. SOUTHALL said that he could not add much to what Mr. Marriott had already shown, but that, of course, the frost had affected different neighbourhoods to different extents. At his own residence at Ross a magnificent magnolia on the house had been entirely blackened. He did not remember ever seeing a similar result before. On the other hand, many of the exotics were uninjured owing to their not having been so forward. In 1847 and 1849 there had been very severe frosts, and in 1837 frosts even more severe, but these had not done so much damage because the preceding weather had not been so mild, and therefore the crops had been less advanced when the cold weather came.

Mr. B. LATHAM observed that one remarkable incident during the late severe frost had been the comparatively high earth temperatures, and that at depths of 2 ft. 6 ins. and 5 ft. the temperatures had remained very much above the average, which no doubt accounted for the forwardness of the vegetation and crops. The damage done by the cold snap in his own neighbourhood at Croydon had been great, and horse chestnut trees had in some cases been turned brown, and the coming blooms all destroyed. The plum and pear crops were completely done for. A few cherries existed, the gooseberries were not so bad, and possibly the apples, which bloomed a little later, and were therefore less severely hit, might yield a crop.

Mr. C. HARDING said that at Greenwich the night temperatures at Easter were 10° colder than at Christmas. He had been staying during Easter at Macclesfield, where the instruments in the West Park were remarkably well placed, and on the night April 12-13 these had shown a shade temperature of 27°, and on the night of 13-14, 30°. Hail showers were very frequent on Easter Sunday, the 12th. On the Monday morning following there were 2½ to 3 ins. of snow upon the ground, and the next morning the snowfall was

renewed, and the unusual phenomenon of fruit-trees in full bloom covered with snow was to be seen. In one particularly bleak spot between Macclesfield and Buxton he had come upon a tub of frozen water, and had found the ice on it so thick that he had great difficulty in breaking it with a strong stick. Charts of the North Atlantic being prepared at the Meteorological Office show strong Easterly winds blowing over the whole belt of the Atlantic to the westward of our coasts on April 9, and on subsequent days there was a long arm of North-westerly and Northerly wind which had been drawn down from the Arctic regions over our islands, and a large area of high barometer readings was situated in the Atlantic to the westward of our islands, and this probably accounted in great measure for the severity of the weather over the United Kingdom.

Mr. D. W. Horner stated that, so far as he could observe, the cherry crop in Kent was in fairly good condition, and seemed but little damaged, but that, speaking for himself, he could testify to the keenness of the wind during the period, as it had penetrated two overcoats and a thick jacket.

Mr. F. Druce, in a note to the Secretary, said :—"I was staying for Easter on Holmbury Hill, near Dorking, between that place and Ockley. The weather became very cold on Sunday, April 12. On the 13th there were frequent showers of snow and graupel. In the middle of the day we could see the Sussex Downs white with the snow. I specially remarked that early in the day snow frequently fell from (apparently) a clear sky, possibly the snow had been carried a considerable distance by a high blustering wind. There were many complaints of early potatoes being cut off by the frost at night. On the 14th there were more snow showers, but lighter."

Mr. R. Bentley, in a similar communication, illustrated the severity of this frost at a critical period before the spring growth was hardened, by mentioning the total destruction of twenty out of twenty-four young larch trees in a plantation, which had been growing vigorously for five or six years previously. Not only the new growth but also the parent stems suffered.

Cricket and Rainfall.—The experience of one or two speculative underwriters at Lloyd's during the past cricket season has caused some amusement. A good deal of business is done in indemnifying cricket clubs from loss in case rain prevents important matches from being played, and in most seasons such underwriting at substantial rates is not unprofitable. This season has upset all ordinary experience by yielding an extravagant number of claims. A large advance in premiums having proved useless, an attempt was made to keep down claims by specifying the amount of rain which must fall on a cricket pitch before a claim would be paid. At first half an inch was fixed, and then one inch; and the story is told of one underwriter who in despair demanded a *minimum* of two inches and promptly got a claim the next week.—*The Times*, September 21, 1903.

Lightning Photography.—Instantaneous photography by natural lightning is the latest curiosity of atmospheric phenomena. During a shooting competition at Pont, in the Canton Vaud, the other day, the grand stand was struck by lightning, and 25 persons received shocks, from which, however, they sustained but little physical injury. One most singular effect, however, remained. Every person who had felt the electric shock had, photographically stamped, either upon the back, the face, or the arms, the reflection of the pine trees behind the firing line.—*Herts Mercury*, September 12, 1903.

[For an account of a similar occurrence in which arborescent or tree-like markings were seen on the body of a boy struck by lightning, see *Quarterly Journal of the Royal Meteorological Society*, vol. xvi. p. 154.—Editors.]

DESCRIPTIONS OF THE DINES-BAXENDELL ANEMOGRAPH, AND THE DIAL-PATTERN NON-OSCILLATING PRESSURE-PLATE ANEMOMETER.

By JOSEPH BAXENDELL, F.R.Met.Soc.

[Read June 17, 1903.]

On April 20, 1892, Mr. Dines communicated to the Society [1] the first description of his now well-known Pressure-Tube Recording Anemometer. Since then, that instrument has undergone various constructional modifications that appeared necessary or desirable in order to fit it for general use, but its essential features have remained quite unchanged. It has been adopted as the standard Anemometer at numerous stations in this country, and is far from being unknown abroad. All meteorologists who, in addition to being familiar with its delicately detailed records, distinctly understand its principle, and are also aware of the care with which its constants were determined, will, I think, readily admit its decided superiority to other forms of Anemometers, and its claim to be regarded as the accepted new standard instrument for recording wind movement in this country. A most important point in its favour is the facility with which its "head" can be erected at almost any height above the ground, or a building, that may be necessary for the purpose of securing a satisfactory exposure.

The use of the Pressure-Tube Anemometer has, however, been attended, at the newer stations, by one drawback. In the various old-type Anemographs a continuous record of Direction was associated with that of Velocity or Pressure. With the new (Tube) instruments, the Direction record has, of course, been lacking.

On June 21, 1899, I ventured to describe to the Society [2] a Recording Anemoscope, which I had designed, and had erected at Marshside, Southport, in close proximity to the Pressure-Tube Anemometer there, with the object of obtaining records of Wind Direction of a similarly delicate and detailed character to those of Velocity and Pressure furnished by the latter (the Dines) instrument. Although my new Anemoscope has acted quite satisfactorily, and others subsequently made, and mounted elsewhere, have given equally good results; and although, further, in consequence of my vane having been fixed at a lower level than the Tube-Anemometer head, no occasional sheltering of one instrument by the other, of any consequence, has arisen, I have nevertheless always much regretted the apparent necessity for two separate vanes and heads, on separate standards, requiring numerous guy-wires, and thus increasing the initial expense, besides also probably interfering with the exposure of any third instrument, *e.g.* a Pressure-Plate Anemometer, which it might be desired to erect at the same station.

The object of the first portion of the present communication is to describe a newly designed "Combined Head," which entirely overcomes the difficulty just mentioned. The upper or out-door portions and

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xviii. p. 165.
[2] *Quarterly Journal of the Royal Meteorological Society*, vol. xxv. p. 326.

mountings of the two instruments have now been combined together so as to form a single erection, consisting of one vane and one compound head, on one standard, capable of accurately actuating the recording and indicating portions of all or any forms of both the Dines Pressure-Tube Anemometer and my Direction instrument (or Anemoscope). On, and to revolve round, the same standard, some five or six feet below the Combined Vane, I have placed the improved form of the Dines Non-Oscillating Pressure-Plate Maximum Anemometer, to be described later on in this paper. The Combined Head can, however, obviously be used without the addition of the Pressure-Plate, and will, indeed, doubtless generally be so employed; while, on the other hand, the Plate is susceptible of erection quite independently, on any ordinary pole or pillar. But in the case of an Observatory adopting all three instruments, it is evident that it will be a material advantage to have the Plate on the same upright as, and directly beneath, the Combined Head, so that a given gust may affect each instrument simultaneously and to a similar extent, and no neighbouring pole will exist to occasion possible interference.

The general outline of the complete combination is shown in Fig. 1. A is the combined vane for the Dines Pressure-Tube Anemometer and my Anemoscope, and B the remainder of the Compound Head; C is the improved, or Dial-Pattern, Non-Oscillating Pressure-Plate Maximum Anemometer; while D represents a 50-foot high 3-inch gas-barrel pillar, on which A, B, and C are mounted, and outside which are secured the iron or composition pressure and suction pipes of the Dines Anemometer; the whole being suitably guyed immediately below the plate C, and again half-way down the pillar. (The guying arrangements are not shown in the drawing.) E is the indoor recording apparatus (of the usual pattern) for the Dines Pressure-Tube Anemometer, and F that for the Baxendell Anemoscope. The direction spindle actuating the latter will be seen coming down the centre of the pillar D.

The details of the Combined Head are shown in Fig. 2. A light but large double-bladed spread vane **k** has for its pointer end a tube **l**, open at the extremity, and also at the inner end, but at the latter turned at right angles so as to revolve on another pipe **m** concentric with the axis of the vane; through these pipes **l**, **m** a free passage for the pressure of the wind at the mouth is obtained to the pressure-tube **n** connected to the float in the recording apparatus of the Dines Pressure-Tube Anemometer. The vane **kl** revolves on ball-bearings **o**, and is secured by means of the spindle **p** to the recording apparatus of the Baxendell Anemoscope. Outside the tube **m**, and concentric with it, is a wider tube **q**, there being thus formed an annular space, which is closed at its upper end, but connected downwards, through the suction tube **r**, to the space over the float in the recording portion of the Dines Anemometer; around this outer tube **q**, at a point opposite an inner weather guard **s**, are drilled the small holes, upon blowing over which the wind exerts a slight sucking action; the weather guard **s** prevents rain running down from these holes to the recorder. The wind pressure in the pipe **m** is prevented from leaking out, at the free bearings of the vane and spindle, by blades working in mercury traps **t**, **t**.

As a result of experiments made at Marshside at the suggestion of Mr. R. H. Curtis, F.R.Met.Soc., it has been definitely ascertained that

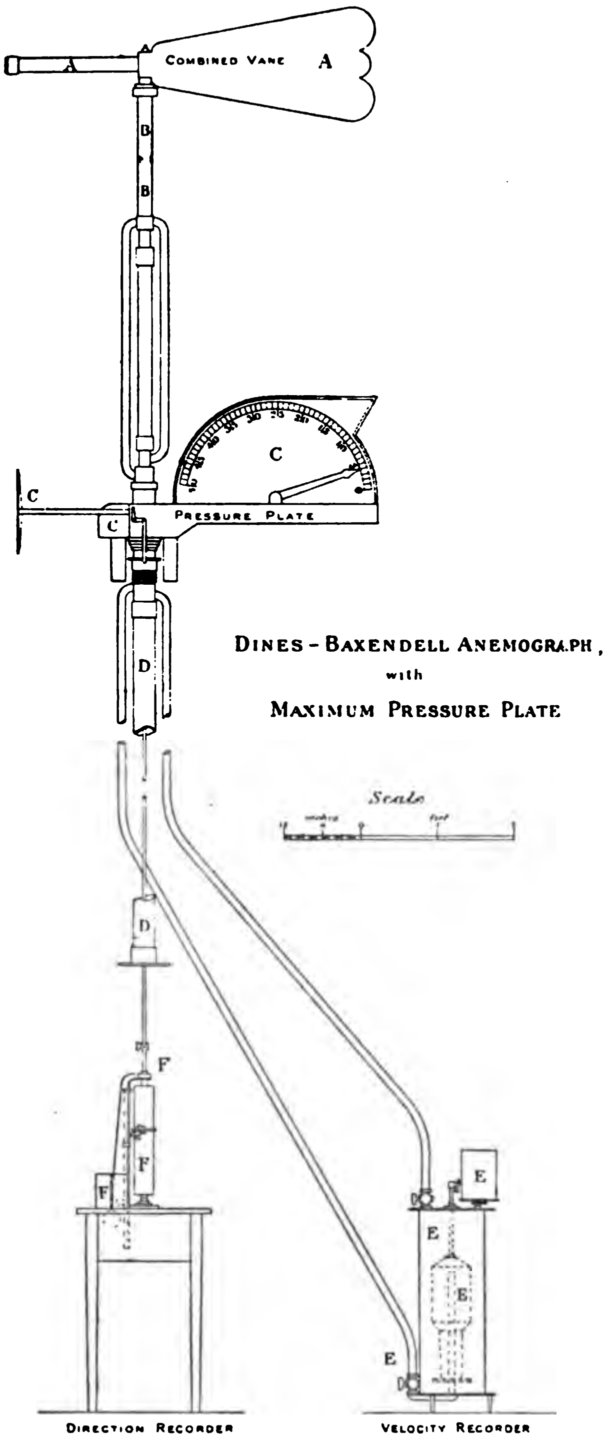
Combined Vane
A
B
B
C
C
C
Pressure Plate
D
Dines - Baxendell Anemograph,
with
Maximum Pressure Plate
Scale
D
F
F
F
E
E
E
E
Direction Recorder
Velocity Recorder

Fig. 1.

DETAILS OF
COMBINED VANE and HEAD,
for
DINES - BAXENDELL ANEMOGRAPH.

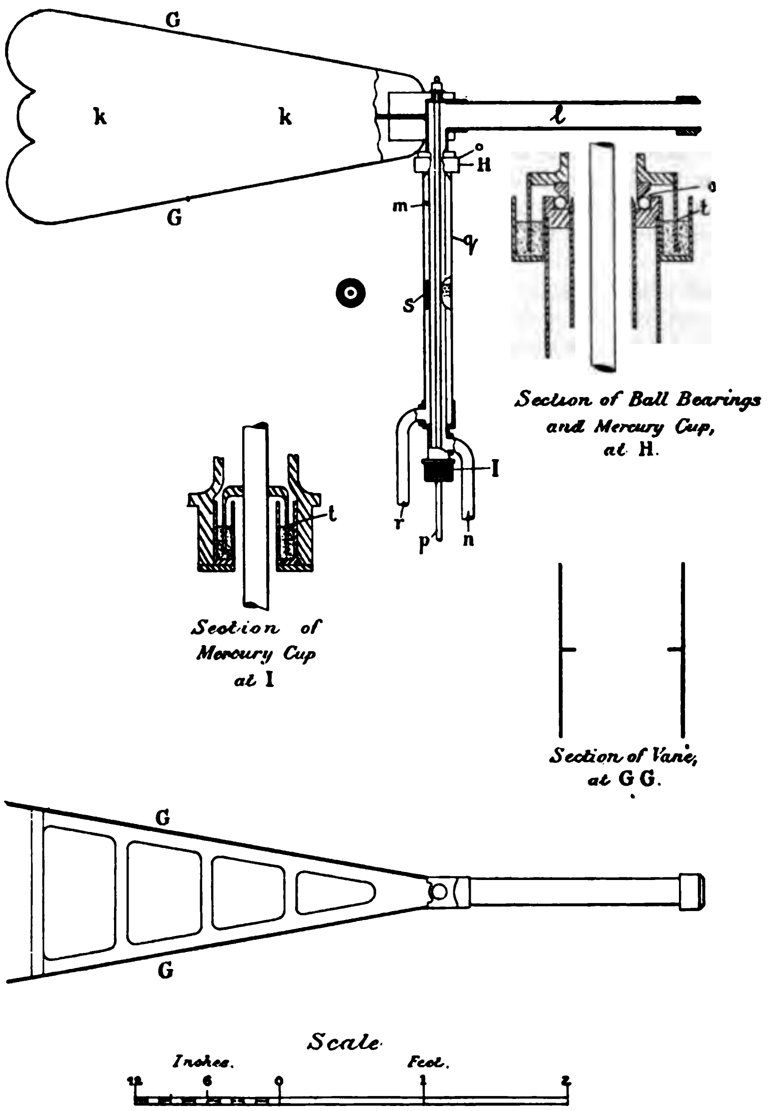

FIG. 2.

the half-inch connecting pipes, and small head, and still smaller-bore unions and cocks, hitherto generally adopted for the Dines Anemometer, unfairly damp the oscillations of the float, so that the pen excursions are smaller, and the maxima recorded lower, than they ought to be. Mr. Dines has consistently maintained that uniformly accurate maxima cannot under any circumstances be obtained with the Tube, or any other, continuously recording anemometer. The Non-Oscillating Pressure-Plate about to be described has, however, shown that maxima in general very closely approximating to the truth are obtainable with the Tube Anemometer if one-inch connecting pipes, and fully equivalent air-ways through the head, unions, and cocks, are adopted in its construction. This accordingly has been done in the case of the new combined instrument.

It has also been ascertained at Marshside that the annular space between the suction holes and the inner weather guard, in the ordinary type of head for the Dines Anemometer, has hitherto been too small, with the result that, in certain winds, even the mean velocities recorded by those instruments have been reduced by one or more miles. The larger dimensions of the Combined Head render it free from this source of error.

Finally, it has several times occurred that, upon the dying out of, say, a sea breeze, and its being replaced by a light, almost exactly opposite, land air in the night, the very short single vane of the ordinary Dines Anemometer has failed for hours to turn at all, notwithstanding its being thoroughly clean and in perfect order. The large spread vane I have adopted almost invariably responds at once on such occasions. Though thoroughly steady in all winds (if well exposed), it is yet very sensitive.

The Non-Oscillating Pressure-Plate Anemometer.

In the course of a paper read before the Society on March 21, 1894,[1] Mr. Dines expressed his belief (the result of a thorough investigation of the subject) that the momentum of the ordinary pressure-plate often adds 30 to 50 per cent to the real pressure, and that the sudden jerk transmitted through the chain or wire (as at Bidston) often brings the pen or pencil another 50 per cent above its proper place. He then remarked: "The pressure-plate is a most useful anemometer and gives most interesting results, including a perfectly accurate mean pressure. If it were provided with a rack and catch, so that it could not oscillate, but once driven back by the wind could not return until set by the observer, the record of the mean would be lost, but the record of the maximum would be reliable."

Subsequently, at the request of the Meteorological Council, Mr. Dines prepared drawings for such a Non-Oscillating Maximum Pressure-Plate Anemometer; and in due course the instrument was constructed, and erected near to the Pressure-Tube and Bridled Anemometers at Salt Island, Holyhead. A description of the instrument, drawn up by Mr. R. H. Curtis, formed part of Note A to the *Report of the Meteorological Council* for 1897-98. The results obtained by the use of this instrument

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xx. p. 180.

fully bore out Mr. Dines' statements and opinions; and, at his suggestion, a similar plate, embracing certain improvements, was, some three years ago, erected at the Marshside Anemograph Station that is associated with the Fernley Observatory, Southport. The rack and catch were replaced by a sliding rod and an inclined metal washer friction-clutch, enabling the maxima to be registered to tenths of a pound; and the moving parts, etc., were carefully balanced. The indications of this instrument were even more encouraging than those of the earlier, or Holyhead one, but undesirable friction was necessarily present, and there were some other slight drawbacks. The Dial-Pattern Non-Oscillating Pressure-Plate now to be described is the result of an effort to overcome these remaining difficulties, and to produce an accurate maximum anemometer suitable for general use.

To make matters perfectly clear, a few fuller preliminary remarks as to the principle of the Non-Oscillating Pressure-Plate may perhaps be permitted.

The essential feature of the apparatus is the passing of a rod (attached to the plate and spring) through an inclined metal washer, so arranged as to permit the free expansion of the spring, while entirely preventing its subsequent contraction on pressure decreasing, thus holding the spring, and a suitable index, at the highest point reached. Accordingly, the index is advanced (over a graduated scale) little by little, each step amounting only to the excess of the pressure of any given gust over that of the strongest previous one experienced by the instrument since the rod and spring were last released by the observer and set. In this way the effects of both momentum and jerk, which, in the case of sudden violent gusts, introduce such large errors into the indications of the older Pressure-Plate Anemometers that are free to oscillate ceaselessly, are almost entirely avoided. Special efforts are also made to render the plate and other moving parts as light as possible, both in order to prevent any material momentum-excess in each advance to a higher gust (small though those advances usually are), and also with a view to reducing friction to a minimum, in the hope that the incessant vibration of the pole may overcome it in all but the lightest winds.

The details of the new or Dial-Pattern form of this Non-Oscillating Maximum Pressure-Plate Anemometer are shown in Fig. 3. A light circular plate 1, having an area equal to one square foot, is kept facing the wind by means of a vane 2; the plate is mounted on two light horizontal rods 3 running freely between rollers. These rods 3 are rigidly attached, by means of a cross-bar 4, to one end of a horizontally-placed strong helical spring 5, the other end of which is secured to the main casting of the instrument; accordingly, an increase in the pressure of the wind on the plate 1 occasions a proportionate extension of the spring. On the other hand, the plate and rods are unable to return on pressure decreasing, being held at the farthest point reached by means of a friction-clutch, which, while freely allowing extension of the spring on pressure increasing, will not permit the smallest contraction or return movement until a release is effected by hand. The friction-clutch adopted consists of an inclined metal washer 6, having a hole in its centre, through which passes a rod 7, which rod is secured to the plate-rods 3 by the cross-bar 4. The lower edge of this washer 6 is held in position by a

hinge, while the upper edge is free to move, within limits, but is kept in a diagonal position, as shown, by a light spring. Consequently, any movement caused by increasing wind pressure on the plate 1 frees the

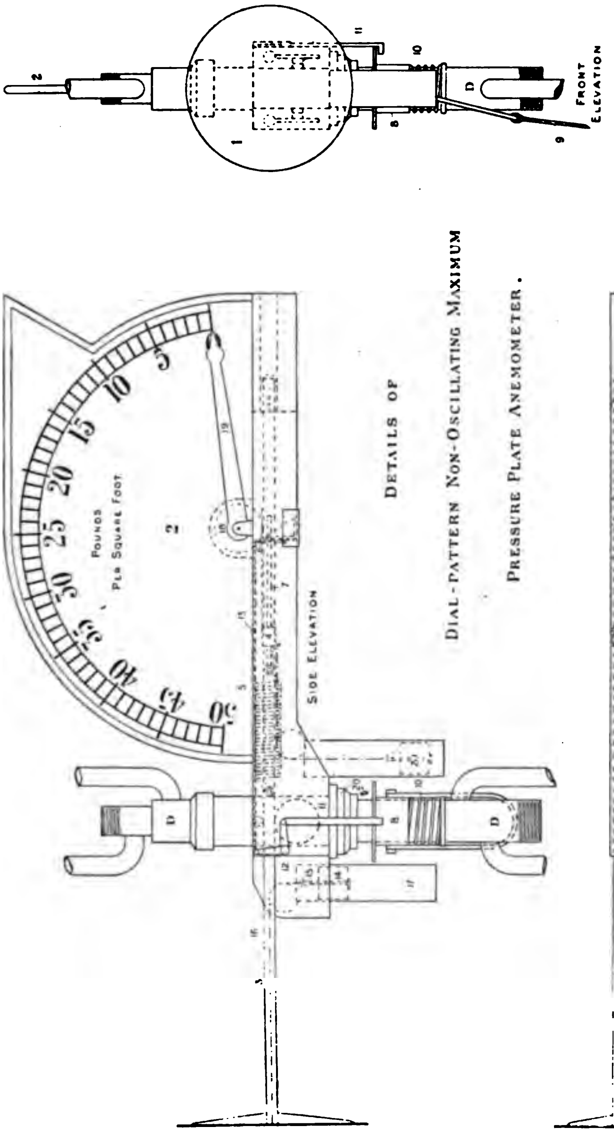

Fig. 3.

rod 7, while a reverse motion instantly locks it. The releasing arrangement, by which the instrument is "set" by hand after a reading has been taken, consists of a lever-connection to the clutch 6 from a sliding collar 8, the latter being mounted on the standard D underneath the Plate

Anemometer, and worked from the ground level or any convenient position by means of a cord 9, being held up by a strong spring 10; the flange of this collar engages with the hooked end of a rod 11, which, by means of a bell-crank lever 12, imparts to a releasing-rod 13 the motion it receives on the cord 9 being pulled down. The plate 1 and the index are thus returned by the observer to their zero positions (or to the positions corresponding to the pressure of the wind at the moment). A piston 14, connected to the moving parts by a piston-rod 15 and a cord 16, and working in fluid in a dash-pot 17, prevents too rapid or violent motion of the various parts on the release of the rod 7 and the extended spring 5 being effected. (When pressure increases, the piston-rod, which passes loosely through the piston and terminates in a loose washer underneath it, falls promptly through the fluid in the dash-pot, without waiting for the gradual descent of the piston.)

Attached to the plate-rods 3, and moving with them, is a rack, which engages with a toothed wheel 18; to the axis of this wheel are secured two fingers 19, which traverse dials on the front and back of the vane 2. The dials are graduated experimentally to show, by the position of the fingers 19, the maximum wind pressure in lbs. per sq. ft. that has been exerted on the plate 1 since the instrument was last set. The dial which happens to be most conveniently situated for observation at the time is read from below by means of a field-glass, the divisions being amply large enough to enable this to be done with accuracy. In taking a reading the lb. divisions are divided by estimation to tenths. The setting-cord 9 is protected from the weather (the wind in particular) by passing down through a small vertical tube attached to the standard D.

The whole of the Anemometer, except the sliding collar 8 and the cord 9, revolves on ball-bearings, 20. The apparatus is shown in the figure as being mounted on the standard D, and to enable this to be done the pressure and suction tubes for the Dines Pressure-Tube Anemometer are, for a short distance, given the forms of annular spaces produced by encircling the standard D with two successively larger concentric iron pipes. It will, however, be obvious that the Non-Oscillating Pressure-Plate Anemometer is capable of being mounted and used quite independently on the top or any part of any standard or pole, and in exposed localities far removed from any building or hut; or it may be fixed on the same standard as, and but a few feet below, almost any type of anemometer or anemoscope.

The mechanical details of the new instrument are really very simple; and it is so constructed that access can readily be gained to all parts without dismounting the anemometer.

Ordinarily, owing to the lightness of the moving parts and the smallness of each advance to a higher gust, it is impossible for momentum to appreciably affect the maximum pressures registered. But it is possible that in some isolated squalls, generally unconnected with severe gales, larger sudden advances do occur, and therefore a damping piston, 21, has been provided, constructed on the same principle as the setting dash-pot 17, but acting in the opposite direction. It can, however, be detached by the possessor of the instrument, by whom its use is optional. As a rule, the daily maxima will be found to be nearly the same whether it is in action or not.

It only remains for me to add that the Combined Head and the improved Pressure-Plate Anemometer have been carefully and satisfactorily constructed by Mr. F. L. Halliwell, to whom, indeed, I am indebted for invaluable assistance in connection with the arrangement of the mechanical details.

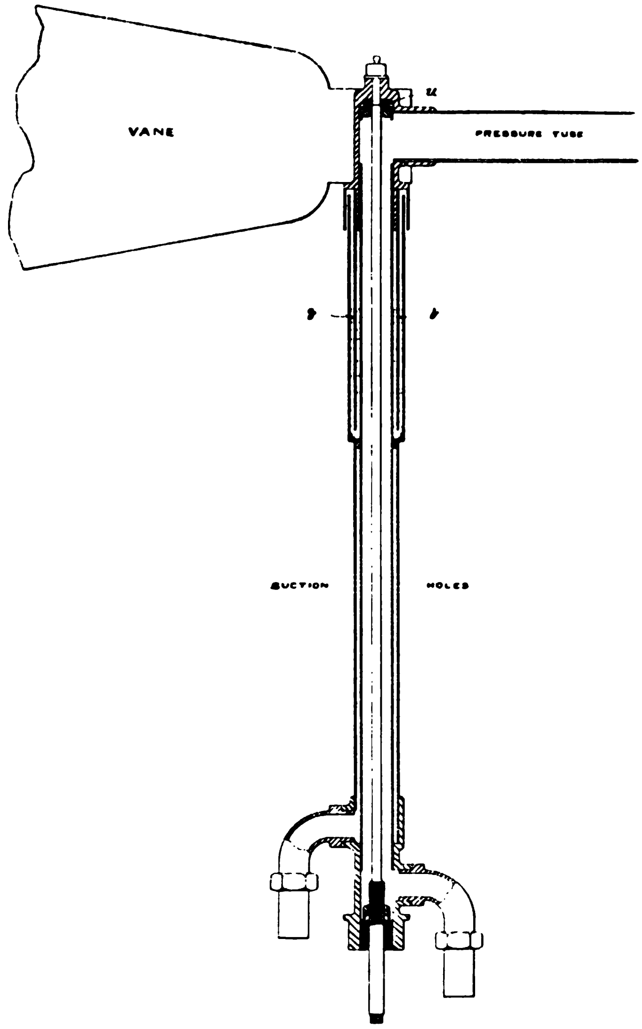

FIG. 4.

ADDENDUM.

Since the foregoing was written, Mr. Halliwell has materially improved the Combined Head, by locating the ball-bearing of the vane in a position *above* the centre of gravity of the revolving portion of the "head," thus increasing the balance and stability, and rendering the instrument even more sensitive in very light winds than before. In addition, the upper

mercury trap has been replaced by a long brine trap; the diameter of the outer pipe in the neighbourhood of the suction holes being reduced so as to be practically identical with that of the corresponding portion of the heads in general use with the Dines Pressure-Tube Anemometers.

As Mr. Dines considers the improvement to be of considerable importance, a sketch of the final form of the "head" is appended (Fig. 4).

U indicates the new position of the ball bearing, carrying the vane and spindle, and VV the long brine trap.—*October* 9, 1903.

The Employment of Means in Meteorology.—Those who make use of the results of meteorological research without being themselves experts in that science, must frequently have experienced a doubt as to the justification for the general use of mean values of meteorological elements, as representing the normal or most probable values for such elements. The same doubt has forced itself upon the mind of the well-known French meteorologist, Prof. Angot, who points out in the *Comptes Rendus* of the Paris Academy of Sciences (May 18, 1903) that such use of means could only be considered legitimate if it were shown that the natural causes which bring about a variation from the mean act in precisely the same way as the purely fortuitous causes which operate generally in cases of variation. In order to test the actual existence of this condition he has examined the records of temperature for France for the fifty years 1851-1900, obtaining the mean for each month, and the actual deviations from the mean, and thus deducing the probable error in any particular case. He has then found the number of observations (out of the total of 600) in which the actual deviation from the mean has equalled or exceeded various multiples of the calculated probable error, and compared the results with those deduced theoretically in the case of purely fortuitous causes of variation. The agreement is surprisingly complete, and Prof. Angot concludes that for France, at least, the arithmetical mean of the temperatures observed for any given month for a series of years is at the same time the most probable value of such temperature, and the one which will occur most frequently. The employment of means is therefore justified for France and for the particular meteorological element in question, but Prof. Angot notes that in the case of rainfall the significance of the mean is more than open to doubt. This seems borne out by the recent calculation of the mean rainfall of London for a series of years, given in *British Rainfall* for 1902, which shows that the results on the basis of 90 years' observations are decidedly different from those on one of 60. Prof. Angot also notes that his period of fifty years is not sufficiently long to give the absolute mean with any great exactness. Would it not, however, be the case that, granted the possibility of long-period variations of climatic elements, the mean obtained from observations within a less number of years would give more nearly the probable value of any element within the same period than one based on a longer series?—*Geographical Journal*, London, September 1903.

METHODS OF METEOROLOGICAL INVESTIGATION.

ADDRESS DELIVERED BY W. N. SHAW, Sc.D., F.R.S.,

Chairman of the Sub-section, Astronomy and Meteorology, at the Meeting of the British Association for the Advancement of Science, at Southport, September 11, 1903.

IN opening the proceedings of the Sub-section devoted to Cosmical Physics, which we may take to be the application of the methods and results of Mathematics and Physics to problems suggested by observations of the earth, the air, or the sky, I desire permission to call your attention to some points of general interest in connection with that department which deals with the air. My justification for doing so is that this is the first occasion upon which a position in any way similar to that which I am now called upon to fill has been occupied by one whose primary obligations are meteorological. That honour I may with confidence attribute to the desire of the Council of the Association to recognise the subject so admirably represented by the distinguished men of science who have come across the seas to deliberate upon those meteorological questions which are the common concern of all nations, and whom we are specially glad to welcome as members of this Sub-section. Their presence and their scientific work are proof, if proof is required, that meteorologists cannot regard meteorological problems as dissociable from Section A; that the prosecution of meteorological research is by the study of the kinematics, the mechanics, the physics, or the mathematics of the data compiled by laborious observation of the earth's atmosphere.

But this is not the first occasion upon which the Address from the Chair of the Sub-section has been devoted to Meteorology. Many of you will recollect the trenchant manner in which a university professor, himself a meteorologist, an astronomer, a physicist, and a mathematician, dealt candidly with the present position of Meteorology. After that Address I am conscious that I have no claim to be called a meteorologist according to the scientific standard of Section A. Professor Schuster has explained—and I cannot deny it—that the responsible duty of an office, from which I cannot dissociate myself, is signing weather reports; and I could wish that the duty of making the next Address had been intrusted to one of my colleagues from across the sea. But as Professor Schuster has set forth the aspect of official meteorology as seen from the academic standpoint with a frankness and candour which I think worthy of imitation, I shall endeavour to put before you the aspect which the relation between Meteorology and academic science wears from the point of view of an official meteorologist whose experience is not long enough to have hardened into that most comfortable of all states of mind, a pessimistic contentment.

Meteorology occupies a peculiar position in this country. From the point of view of Mathematics and Physics, the problems which the subject presents are not devoid of interest, nor are they free from that difficulty which should stimulate scientific effort in academic minds. They afford a most ample field for the display of trained intellect, and even of genius, in devising and applying theoretical and experimental methods. And can we say that the work is unimportant? Look where you will over the countries which the British Association may be supposed to represent, either directly or indirectly, and say where a more satisfactory knowledge of the laws governing the weather would be unimportant from any point of view. Will you take the British Isles on the eastern shores of the Atlantic, the great meteorological laboratory of the world, with the far-reaching interests of their carrying trade; or India, where the phenomena of the monsoon show most conspicuously the effects of the irregular

distribution of land, the second great meteorological cause, and where recurring famines still overstrain the resources of administration. Take the Australasian colonies and the Cape, which, with the Argentine Republic, where Mr. Davis is developing so admirably the methods of the Weather Bureau, constitute the only land projections into the great southern ocean, the region of "planetary meteorology"; Australia, with its periods of paralysing drought; the Cape, where the adjustment of crops to climate is a question of the hour; or take Canada, which owns at the same time a granary of enormous dimensions and a large portion of the Arctic Circle; or take the scattered islets of the Atlantic and Pacific or the shipping that goes wherever ships can go. The merest glance will show that we stand to gain more by scientific knowledge, and lose more by unscientific ignorance of the weather, than any other country. The annual loss on account of the weather would work out at no inconsiderable sum per head of the population, and the merest fraction of success in the prevention of what science must regard as preventible loss would compensate for half a century of expenditure on meteorological offices. Or take a less selfish view and consider for a moment our responsibilities to the general community of nations, the advantages we possess as occupying the most important posts of observation. If the meteorology of the world were placed, as perhaps it ought to be, in the hands of an International Commission, it can be no exaggeration to say that a considerable majority of the selected sites for stations of observation would be on British soil or British ships. We cannot help being the most important agency for promoting or for obstructing the extension of meteorological science. I say this bluntly and perhaps crudely, because I feel sure that ideas not dissimilar from these must occasionally suggest themselves to every meteorologist, British or foreign; and if they are to be expressed—and I think you will agree with me that they ought to be—a British meteorologist ought to take the responsibility of expressing them.

And how does our academic organisation help us in this matter of more than parochial or even national importance? There was a time when Meteorology was a recognised member of the large physical family and shared the paternal affection of all professors of Physics; but when the poor nestling began to grow up and develop some individuality, electricity developed simultaneously with the speed of a young cuckoo. The professors of Physics soon recognised that the nest was not large enough for both, and with a unanimity which is the more remarkable, because in some of these academic circles utilitarianism is not a condition of existence, and pure science, not market value, might be the dominant consideration—with singular unanimity the science which bears in its left hand, if not in its right, sources of wealth beyond the dreams of avarice, was recognised as a veritable Isaac, and the science wherein the fruits of discovery must be free for all the world, and in which there is not even the most distant prospect of making a fortune—that science was ejected as an Ishmael. Electrical engineering has an abundance of academic representatives; brewing has its professorship and its corps of students, but the specialised physics of the atmosphere has ceased to share the academic hospitality. So far as I know, the British universities are unanimous in dissembling their love for Meteorology as a science, and if they do not actually kick it downstairs, they are at least content that it has no encouragement to go up. In none is there a professorship, a lectureship, or even a scholarship, to help to form the nucleus of that corps of students which may be regarded as the primary condition of scientific development.

Having cut the knot of their difficulties in this very human but not very humane method, the universities are, I think, disposed to adopt a method of justification which is not unusual in such cases; indications are not wanting which disclose an opinion that Meteorology is, after all, not a science. There

are, I am aware, some notable exceptions; but do I exaggerate if I say that when university professors are kind enough to take an interest in the labours of meteorologists, who are doing their best amid many discouragements, it is generally to point out that their work is on the wrong lines; that they had better give it up and do something else? And the interest which the universities display in a general way is a good-humoured jest about the futility of weather prophecy, and the kindly suggestion that the improvement in the prediction of the next twenty-four hours' weather is a natural limit to the orbit of an Ishmaelite's ambition.

Under these circumstances, such an Address as Professor Schuster's is very welcome: it recognises at least a scientific brotherhood and points to the responsibility for a scientific standard; it even displays some of the characteristics of the Good Samaritan, for it offers his own beast on which to ride, though it recommends the unfortunate traveller to dispose of what little clothing the stripping has left to provide the two pence for the host.

It is quite possible that the unformulated opinion of the vast majority of people in this country who are only too familiar with the meteorological vagaries of the British Isles is that the weather does just as it pleases; that any day of the year may give you an August storm or a January summer's day; that there are no laws to be discovered, and that the further prosecution of so unsatisfactory a study is not worth the time and money already spent upon it. They forget that there are countries where, to judge by their languages, the weather has so nearly the regularity of "old time," that one word is sufficient to do duty for both ideas. They forget that our interests extend to many climates, and that the characteristics of the eastern shores of the North Atlantic are not appropriate to, say, western Tropical Africa. That may be a sufficient explanation of the attitude of the man in the street, but as regards the British universities, dare I offer the difficulty of the subject as a reason for any want of encouragement? Or shall I say that the general ignorance on the part of the public of the scientific aspirations and aims of meteorologists and of the results already obtained is a reason for the universities to keep silence on the subject? With all respect, I may say that the aspect which the matter presents to official meteorologists is that the universities are somewhat oblivious of their responsibilities and their opportunities.

I have no doubt that it will at once be said that Meteorology is supported by Government funds, and that alma mater must keep her maternal affection and her exiguous income for subjects that do not enjoy State support. I do not wish just now to discuss the complexities of alma mater's housekeeping. I know she does not adopt the same attitude with regard to astronomy, physics, geology, mineralogy, zoology, or botany, but let that pass. From the point of view of the advancement of science, I should like to protest against the idea that the care of certain branches of science by the State and by the universities can be regarded as alternative. The advancement of science demands the co-operation of both in their appropriate ways. As regards Meteorology, in my experience, which I acknowledge is limited, the general attitude towards the department seems to be dictated by the consideration that it must be left severely alone in order to avoid the vicious precedent of doing what is, or perhaps what is thought to be, Government work without getting Government pay, and the result is an almost monastic isolation.

There is too much isolation of scientific agencies in this country. You have recently established a National Physical Laboratory, the breath of whose life is its association with the working world of physics and engineering, and you have put it—where? At Cambridge, or anywhere else where young physicists and engineers are being trained? No; but in the peaceful seclusion of a palace in the country, almost equidistant from, academically speaking, Cambridge,

Oxford, London, and everywhere else. You have established a Meteorological Office, and you have put it in the academic seclusion of Victoria Street. Monastic isolation may have its advantages, but I am perfectly certain it is not good for the scientific progress of Meteorology. How can one hope for effective scientific development without some intimate association with the institutions of the country which stand for intellectual development and the progress of science?

I could imagine an organisation which by association of the universities with a central office would enable this country, with its colonies and dependencies, to build up a system of meteorological investigation worthy of its unexampled opportunities. But the co-operation must be real and not one-sided. Meteorology, which depends upon the combination of observations of various kinds from all parts of the world, must be international, and a Government department in some form or other is indispensable. No university could do the work. But whatever form Government service takes, it will always have some of those characteristics which, from the point of view of research, may be called bondage. On the other hand, research, to be productive, must be free with an academic freedom, free to succeed or fail, free to be remunerative or unremunerative, without regard to Government audits or House of Commons control. Research looks to the judgment of posterity with a faith which is not unworthy of the churches, and which is not among those excellent moral qualities embodied in the Controller and Auditor-General. *Die academische Freiheit* is not the characteristic of a Government department. The opportunity which gave to the world the *Philosophiæ Naturalis Principia* was not due to the State subvention of the Deputy Mastership of the Mint, but to the modest provision of a professorship by one Henry Lucas, of whose pious benefaction Cambridge has made such wonderful use in her Lucasian professors.

The future of Meteorology lies, I believe, in the association of the universities with a central department. I could imagine that Liverpool or Glasgow might take a special interest in the meteorology of the sea; they might even find the means of maintaining a floating observatory; and when I say that we know practically nothing of the distribution of rainfall over the sea, and we want to know everything about the air above the sea, you will agree with me that there is room for such an enterprise. Edinburgh might, from its association with Ben Nevis, be desirous of developing the investigation of the upper air over our land; in Cambridge might be found the author of a book, on the principles of atmospheric physics, worthy of its Latin predecessor; and for London I can assign no limited possibilities.

If such an association were established, I should not need to reply to Professor Schuster's suggestion for the suppression of observations. The real requirement of the time is not fewer observations, but more men and women to interpret them. I have no doubt that the first expression of such an organisation would be one of recognition and acknowledgment of the patience, the care, the skill, and the public spirit — all of them sound scientific characteristics — which furnish at their own expense those multitudes of observations. The accumulated readings appal by their volume, it is true, but they are, and must be, the foundation upon which the scientific structure will be built.

So far as this country is concerned, when one puts what is in comparison with what might be, it must be acknowledged that the tendency to pessimistic complaisance is very strong. Yet I ought not to allow the reflections to which my predecessor's Address naturally give rise to be too depressing. I should remember that, as Dr. Hellmann said some years ago, Meteorology has no frontiers, and each step in its progress is the result of efforts of various kinds in many countries, our own not excluded. In the presence of our guests to-day, some of whom know by practical experience the advantages of the association of academic liberty with official routine, remembering the recent conspicuous

successes in the investigation of the upper air in France, Germany, Austria, Russia, and the United States, and the prospect of fruitful co-operation of meteorology with the other branches of cosmical physics, I may well recall the words of Clough:

> Say not, the struggle nought availeth . . .
> And as things have been, they remain.
>
> If hopes were dupes, fears may be liars;
> It may be, in yon smoke concealed
> Your comrades chase e'en now the fliers,
> And, but for you, possess one field.
>
> For while the tired waves, vainly breaking,
> Seem here no painful inch to gain,
> Far back, through creeks and inlets making,
> Comes silent, flooding in, the main.
>
> And not by eastern windows only,
> When daylight comes, comes in the light;
> In front, the sun climbs slow, how slowly,
> But westward, look, the land is bright.

Official meteorologists are not wanting in scientific ambitions and achievements. It is true that Professor Hann, whose presence here would have been so cordially welcomed, left the public service of Austria to continue his services to the world of science by the compilation of his great handbook, and Snellen is leaving the direction of the weather service of the Netherlands for the more exclusively scientific work of directing an observatory of terrestrial physics; but I am reminded by the presence of Professor Mascart of those services to meteorological optics and terrestrial magnetism that make his place as President of the International Committee so natural and fitting; and of the solid work of Angot on the diurnal variation of the barometer and the reduction of barometric observations for height that form conspicuous features among the many valuable memoirs of the Central Bureau of Paris.

Of the monumental work of Hildebrandsson in association with Teisserenc de Bort on clouds, which culminated quite recently in a most important addition to the pure kinematics of the atmosphere, I hope the authors will themselves speak. Professor Willis Moore's presence recalls the advances which Bigelow has made in the kinematics and mechanics of the atmosphere under the auspices of Professor Moore's office, and reminds us of the debt of gratitude which the English-speaking world owes to Professor Cleveland Abbé, of the same office, for his treatment of the literature of atmospheric mechanics.

If General Rykatcheff had only the magnificent Climatological Atlas of the Russian Empire to his credit, he might well rest satisfied. Professor Mohn's contributions to the mechanics of the atmosphere are examples of Norwegian enterprise in the difficult problems of Meteorology, while Dr. Paulsen maintains for us the right of meteorologists to share in the results of the newest discoveries in physics. Davis's enterprise in the far south does much to bring the southern hemisphere within our reach, while Chaves places the meteorology of the mid-Atlantic at the service of the scientific world. Need I say anything of Billwiller's work upon the special effect of mountains upon meteorological conditions, or of the immense services of those who co-operate with Hann in the production of the *Meteorologische Zeitschrift*, Professor Pernter of Vienna, and Dr. Hellmann of Berlin; of Palazzo's contributions to terrestrial magnetism? The mention of Eliot's Indian work, or of Russell's organisation of Australian meteorology, will be sufficient to show that the dependencies and colonies are prepared to take a share in scientific enterprise. And if I wished to reassure myself that even the official meteorology of this country is not without its scientific ambitions

and achievements, I would refer not only to Scott's many services to science, but also to Strachey's papers on Indian and British Meteorology, and to the official contributions to Marine Meteorology.

There is another name, well known in the annals of the British Association, that will for ever retain an honoured place among the pioneers of meteorological enterprise—that of James Glaisher, the intrepid explorer of the upper air, the Nestor of official meteorologists, who has passed away since the last meeting of the Association.

I should like especially to mention Professor Hergesell's achievements in the organisation of the international investigation of the upper air by balloons and kites, because it is one of the departments which offers a most promising field for the future, and in which we in this country have a good many arrears to make up. I hope Professor Hergesell will later on give us some account of the present position of that investigation, and I am glad that Mr. Rotch, to whose enterprise the development of what I may call the scientific kite industry is largely due, is present to take part in the discussion.

Yet with all these achievements it must be confessed that the progress made with the problems of general or dynamical Meteorology in the last thirty years has been disappointing. When we compare the position of the subject with that of other branches of Physics, it must be allowed that it still lacks what astronomy found in Newton, sound in Newton and Chladni, light in Young or Fresnel, heat in Joule, Kelvin, Clausius, and Helmholtz, and electricity in Faraday and Maxwell. Above all, it lacks its Kepler. Let me make this clear. Kepler's contribution to physical astronomy was to formulate laws which no heavenly body actually obeys, but which enabled Newton to deduce the law of gravitation. The first great step in the development of any physical science is to substitute for the indescribably complex reality of nature an ideal system that is an effective equivalent for the purposes of theoretical computation. I cannot refrain from quoting again from Plato's *Republic* a passage which I have quoted elsewhere before. It expresses paradoxically but still clearly the relation of natural philosophy to natural science. In the discussion of the proper means of studying sciences Socrates is made to say, "We shall pursue astronomy with the help of problems just as we pursue geometry: but we shall let the heavenly bodies alone if it is our design to become really acquainted with astronomy." What I take to be the same idea is expressed in other words by Rayleigh in the introduction to his *Sound*. He there points out as an example that the natural problem of a sounding tuning-fork really comprises the motion of the fork, the air, and the vibrating parts of the ear; and the first step in sound is to simplify the complex system of nature by assuming that the vibrations of the fork, the air, and the ear can be treated independently. In many sciences this step is a most difficult one to take. What student of nature, contemplating the infinity of heavenly bodies and unfamiliar with this method of idealism, would imagine that the most remarkable and universal generalisation in physical science was arrived at by reducing the dynamics of the universe to the problem of three bodies? When we look round the sciences each has its own peculiar ideals and its own physical quantities: astronomy has its orbits and its momentum, sound its longitudinal vibration, light its transverse vibration, heat its energy and entropy, electricity its "quantity" and its wave, but meteorology has not yet found a satisfactory ideal problem to substitute for the complexity of nature. I wish to consider the aspect of the science from this point of view and to recall some of the attempts made to arrive at a satisfactory modification of reality. I do not wish to refer to such special applications of physical reasoning as may be involved in the formation of cloud, the thermodynamics of a mixture of air and water vapour, the explanation of optical or electrical phenomena, nor even Helmholtz's application of the theory of

gravitational waves to superposed layers of air of different density. These require only conventions which belong already to physics, and though they may furnish suggestions they do not themselves constitute a general meteorological theory.

The most direct efforts to create a general theory of atmospheric circulation are those which attempt to apply Newtonian dynamics, with its more recent developments on the lines of hydrodynamics and thermodynamics. Attempts have been made, mathematical or otherwise, to determine the general circulation of the atmosphere by the application of some form of calculation, assuming only the sun and a rotating earth, with an atmosphere, as the data of the problem. I confess that these attempts, interesting and ingenious as they are, seem to me to be somewhat premature. The "problem" is not sufficiently formulated. When Newton set to work to connect the motions of the heavenly bodies with their causes, he knew what the motions of the heavenly bodies were. Mathematics is an excellent engine for explaining and confirming what you know. It is very rarely a substitute for observation, and before we rely upon it for telling us what the nature of the general circulation of the atmosphere really is, it would be desirable to find out by observation or experiment what dynamical and elastic properties must be attributed to an extremely thin sheet of compressible fluid rotating about an axis with a velocity reaching 1000 miles an hour, and subject to periodic heating and cooling of a very complicated character. It would be more in consonance with the practice of other sciences to find out by observation what the general circulation is before using mathematics to explain it. What strikes one most about the mathematical treatises on the general circulation of the atmosphere is that what is true about the conclusions is what was previously known from observation. It is, I think, clear that that method has not given us the working ideal upon which to base our theory.

Consider next the attempts to regard atmospheric phenomena as periodic. Let me include with this the correlation of groups of atmospheric phenomena with each other or with those of the sun, when the periodicity is not necessarily regular, and the scientific process consists in identifying corresponding changes. This method has given some remarkable results by the comparison of the sequence of changes in the meteorological elements in the hands of Pettersen and Meinardus, and by the comparison of the variation of pressure in different parts of the globe by Sir Norman Lockyer and Dr. W. J. S. Lockyer; as regards the earth and the sun the subject has reached the stage of productive discussion. As a matter of fact, by continuing this Address I am preventing Sir Norman Lockyer from telling you all about it.

For the purpose of dealing with periodicity in any form we substitute for nature an ideal system obtained by using mean values instead of individual values, and leaving out what, from this point of view, are called accidental elements. The simplification is perfectly legitimate. Passing on to the consideration of periodicity in the stricter sense, the process which has been so effective in dealing with tides, the motions of the liquid layer, is very attractive as a means of attacking the problems of the atmosphere, because, in accordance with a principle in dynamics, to every periodic cause there must correspond an effect of the same period, although the relation of the magnitude of the effect to the cause is governed by the approximation of the natural period of the body to that of the cause.

There are two forms of the strict periodic method. One is to examine the generalised observations for periodicities of known length, whether it be that of the lunar rotations or of sunspot frequency, or of some longer or shorter period. In this connection let me acknowledge a further obligation to Professor Schuster for tacking on to his Address of last year a development of his work on the

detection of hidden periodicities, by giving us a means of estimating numerically what I may call the reality of the periodicity. The other method is by harmonic analysis of a series of observations with the view of finding causes for the several harmonic components. I may say that the Meteorological Office, supported by the strong opinion of Lord Kelvin, has favoured that plan, and on that account has for many years issued the hourly results for its observatories in the form of five-day means as representing the smallest interval for which the harmonic analysis could be satisfactorily employed. Sir Richard Strachey has given some examples of its application, and the capabilities of the method are by no means exhausted, but as regards the general problem of dynamic meteorology harmonic analysis has not as yet led to the disclosure of the required generalisation.

I ought to mention here that Professor Karl Pearson, with the assistance of Miss Cave, has been making a most vigorous attempt to estimate the numerical value of the relationship, direct or inverse, between the barometric readings at different places on the earth's surface. The attempt is a most interesting one as an entirely new departure in the direction of reducing the complexity of atmospheric phenomena. If it were possible to find co-ordinates which showed a satisfactory correlation, it might be possible to reduce the number of independent variables, and refer the atmospheric changes to the variations of definite centres of action in a way that has already been approached by Hildebrandsson from the meteorological side.

Years ago, when Buys Ballot laid down as a first law of atmospheric motion [1] that the direction of the wind was transverse to the barometric gradient and the force largely dependent upon the gradient, and when the examination of synchronous charts showed that the motion of air could be classified into cyclonic and anticyclonic rotation, it appeared that the meteorological Kepler was at hand, and the first step towards the identification of a working meteorological unit had been taken—the phenomena of weather might be accounted for by the motion and action of the cyclonic depression, the position of the ascending current, the barometric minimum. The individual readings over the area of the depression could be represented by a single symbol. By attributing certain weather conditions to certain parts of the cyclonic area and supposing that the depression travelled with more or less unchanged characteristics, the vagaries of weather changes can be accounted for. For thirty years or more the depression has been closely watched, and thousands of successful forecasts have been based upon a knowledge of its habits. But unfortunately the travelling depression cannot be said to preserve its identity in any sense to which quantitative reasoning can be applied. As long as we confine ourselves to a comparatively small region of the earth's surface, the travelling depression is a real entity; but when we widen our area it is subject to such variations of path, of speed, of intensity, and of area that its use as a meteorological unit is seriously impaired, and when we attempt to trace it to its source or follow it to its end, it eludes us. Its origin, its behaviour, and its end are almost as capricious as the weather itself.

Nor, if we examine other cases in which a veritable entity is transmitted, can we expect that the simple barometric distribution should be free from inexplicable variations. We are familiar with ordinary motion, or, as I will call it, astronomical motion, wave motion, and vortex motion. Astronomical motion is the motion of matter, wave motion the motion of energy, vortex motion the motion of matter with energy, but the motion of a depression is merely the transmission of the locus of transformation of energy; neither the matter nor the energy need accompany the depression in its motion. If other kinds of motion are subject to the laws of conservation of matter and conservation of energy, the

[1] It may here be remarked that the first person to bring Prof. Buys Ballot's law before the British public was the late Mr. Baxendell of Southport, in 1867. See *Proceedings of the Literary and Philosophical Society of Manchester*, vol. vi. p. 111.

motion of the depression must have regard also to the law of dissipation of energy. An atmospheric disturbance, with the production of rainfall and other thermal phenomena, must comply in some way with the condition of maximum entropy, and we cannot expect to account for its behaviour until we can have proper regard to the variations of entropy. But the conditions are not yet in a form suitable for mathematical calculation, and we have no simple rules to guide us. So far as Meteorology is concerned, Willard Gibbs unfortunately left his work unfinished.

When the cyclonic depression was reluctantly recognised as too unstable a creature to carry the structure of a general theory, Mr. Galton's anticyclones, the areas of high pressure and descending currents, claimed consideration as being more permanent. Professors Köppen and van Bebber have watched their behaviour with the utmost assiduity and sought to find therein a unit by which the atmospheric changes can be classified; but I am afraid that even Dr. van Bebber must allow that his success is statistical and not dynamical. "High pressures" follow laws on the average, and the quantity we seek is not an average but an individual.

The question arises, whether the knowledge of the sequence of weather changes must elude us altogether, or will yield to further search. Is the man in the street right after all? But consider how limited our real knowledge of the facts of atmospheric phenomena really is. It may very well be that observations on the surface will never tell us enough to establish a meteorological entity that will be subject to mathematical treatment; it may be that we can only acquire a knowledge of the general circulation of the atmosphere by the study of the upper air, and must wait until Professor Hergesell has carried his international organisation so far that we can form some working idea therefrom of general meteorological processes. But let us consider whether we have even attempted for surface meteorology what the patience of astronomers from Copernicus to Kepler did for astronomy.

Do we yet fully comprehend the kinematics of the travelling depression; and if not, are we in a satisfactory position for dealing with its dynamics? I have lately examined minutely the kinematics of a travelling storm, and the results have certainly surprised me and have made it clear that the travelling depressions are not all of one kinematical type. We are at present hampered by the want of really satisfactory self-recording instruments. I have sometimes thought of appealing to my friends the professors of physics who have laboratories where the reading of the barometer to the thousandth of an inch belongs to the work of the "elementary class," and of asking them to arrange for an occasional orgy of simultaneous readings of the barometer all over the country with corresponding weather observations for twenty-four consecutive hours, so that we might really know the relation between pressure, rainfall, and temperature of the travelling depressions; but I fear the area covered would even then hardly be large enough, and we must improve our self-recording instruments.

Then, again, have we arrived at the extremity of our knowledge of the surface circulation of the atmosphere? We know a great deal about the average monthly distribution, but we know little about the instantaneous distribution. It may be that by taking averages we are hiding the very points which we want to disclose.

Let me remind you again that the thickness of the atmosphere in proportion to the earth's surface is not unsatisfactorily represented by a sheet of paper. Now it is obvious that currents of air in such a thin layer must react upon each other horizontally, and therefore we cannot *à priori* regard one part of the area of the earth's surface as meteorologically independent of any other part. We have daily synoptic charts for various small parts of the globe, and the Weather Bureau extended these over the northern hemisphere for the years 1875 to

1879; but who can say that the meteorology of the northern hemisphere is independent of that of the southern? To settle that primary question we want a synchronous chart for the globe. As long as we are unable to watch the changes in the globe we are to a certain extent groping in the dark. A great part of the world is already mapped every day, and the time has now arrived when it is worth while to consider what contributions we can make towards identifying the distribution of pressure over the globe. We may idealise a little by disregarding the local peculiarities without sacrificing the general application. I have put in the exhibition a series of maps showing what approximation can be made to an isochronous chart of the globe without special effort. We are gradually extending the possibility of acquiring a knowledge of the facts in that as in other directions. With a little additional enterprise a serviceable map could be compiled; and when that has been reached, and when we have added to that what the clouds can tell us, and when the work of the Aeronautical Committee has so far progressed that we can connect the motion of the upper atmosphere with the conditions at the surface, when we know the real kinematics of the vertical and horizontal motion of the various parts of a travelling storm, we shall, if the universities will help us, be able to give some rational explanation of those periodic relations which our solar physics friends are identifying for us, and to classify our phenomena in a way that the inheritors of Kepler's achievements associated with us in this Section may be not unwilling to recognise as scientific.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 20, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

LIEUT. CHARLES ST. BARBE SLADEN, R.E., Ordnance Survey, Shrewsbury, was balloted for and elected a Fellow of the Society.

The following communications were read:—

1. "THE RELATION OF THE RAINFALL TO THE DEPTH OF WATER IN A WELL." By CHARLES P. HOOKER, L.R.C.P., F.R.Met.Soc. (p. 263).
2. "THE FROST OF APRIL 1903." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 283).

June 17, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

CAPT. CHARLES BARRON, 50 Lister Street, Hull;
GEORGE BURT, Assoc.Inst.C.E., 37 Grosvenor Road, S.W.;
RICHARD AYLMER COATES, West Mount, Dover;
J. WALTER GALLAGHER, Bangkok, Siam;
ADOLPH KRAWEHL, Port Elizabeth, South Africa,
were balloted for and elected Fellows of the Society.

The following communications were read:—

1. "THE METEOROLOGICAL ASPECTS OF THE STORM OF FEBRUARY 26-27, 1903." By W. N. SHAW, Sc.D., F.R.S. (p. 233).
2. "THE DINES-BAXENDELL ANEMOGRAPH, AND THE DIAL-PATTERN NON-OSCILLATING PRESSURE-PLATE ANEMOMETER." By JOSEPH BAXENDELL, F.R.Met.Soc. (p. 289).

CORRESPONDENCE AND NOTES.

British Rainfall Organisation.—We have received the following letter from Mr. H. Sowerby Wallis:—

"62 CAMDEN SQUARE, LONDON, N.W.,
"*September* 1, 1903.

"DEAR SIR,—After thirty years' association with my late friend G. J. Symons in the development of the Rainfall Organisation, by his desire I took up the burden of his work with grave misgivings that my health would not long support the strain.

"Frequent illness now prevents me giving it continuous attention, and for me to remain in charge could only be a source of weakness. I therefore feel that the time has come for me to pass on the control of the work, and I am glad that so able a successor as Dr. Mill is ready to take up the onerous task. I am handing over to him all the records and instruments and leaving this

house, that he may continue the Organisation, without a break, at the old address.

"Dr. Mill has devoted much attention to rainfall, and for three years we have conjointly carried on the work while he acquired that intimate knowledge of detail so essential to ensure continuity on the lines approved by experience.

"In thus taking leave, while naturally regretting the termination of a life-long labour with which many pleasant memories are associated, I would congratulate the nation on possessing a body of private individuals who have, for nearly half a century, kept up a national work of the first importance, and who may be trusted to maintain it in perpetuity.—Yours very truly,

"H. SOWERBY WALLIS."

Investigation of the Upper Atmosphere by Means of Kites.—At the meeting of the British Association at Southport in September 1903, Mr. W. H. Dines presented the following Report of the Committee:—

The results of last year's work have been published; a description of the apparatus and methods employed being given in the *Quarterly Journal of the Royal Meteorological Society*, vol. xxix. No. 126, p. 65; and a discussion of the results obtained in a paper by Dr. Shaw and myself which appears in the *Philosophical Transactions* of the Royal Society, vol. 202, p. 123.

The apparatus used at Crinan last year was erected at Oxshott in the autumn, and it was hoped that to a limited extent the observations might be continued there; but before the end of October the wire was accidentally dropped across the main road leading from Esher to Leatherhead. Fortunately the wire rested on trees on both sides of the road; but before it could be removed many carriages and bicyclists had passed under it. This accident convinced me that it would be unwise to continue the work at Oxshott, excepting for winds between South and North-west, and the winter has been devoted to an endeavour to improve the apparatus.

This I hope has been accomplished: a new winding-gear has been constructed, which so far has given every satisfaction; and the details of the construction of the kites have been altered, so that they exert a more uniform pull and seem to be more reliable. The apparatus was brought to Crinan at the beginning of this month, and in view of the uncertainty about obtaining a vessel, was erected on the same island as last year. The apparatus in the possession of the Committee now consists of—

I. Engine, boiler, and winding-gear used last year.
II. New winding-gear.
III. About 14 miles of wire, six of which have been purchased this year.
IV. Ten kites 7 ft. 6 ins. high; three kites 9 ft. high; and materials of a kite 12 ft. high.
V. Two[1] self-recording instruments made by Mons. Teisserenc de Bort.
VI. Spare bamboo sticks, etc., for repairs.

The old winding-gear is hardly reliable, but many of the parts will be available for making another.

Application was made to the Government Grant Committee of the Royal Society for a grant of £250 for the hire of a vessel. On the suggestion of this Committee the Admiralty were asked to lend a vessel for the purpose, and they had kindly consented to do so; but unfortunately the vessel they proposed to place at the disposal of the Kite Committee has met with an accident and is

[1] A third is promised by him and expected shortly.

unavailable. The Royal Society have, however, made a grant of £200, and I am now endeavouring to hire a suitable vessel.

Addendum to the Report of the Kite Committee.

Great difficulty has been experienced in obtaining a suitable vessel owing to the lateness of the time at which inquiries about one were instituted, and to the fact that July and August are the yachting season. A steam tug, the *Renown*, has been hired for a month, and reached Crinan on August 13. The apparatus was fitted on board by the evening of the 14th, and since then daily ascents have been made. No great height (over 6000 ft.) has been reached, for the weather has been of the most unfavourable description for kite flying; but one very interesting trace has been obtained, namely, that of August 20, when the kite was drawn in from a height of 4500 ft. during a sudden and unexpected thunderstorm which was accompanied by extremely violent rain and hail. W. H. DINES.

August 21, 1903.

Kite Competition.—The Kite Competition for the silver medal of the Aeronautical Society of Great Britain took place on Thursday, June 25, on the Sussex Downs at Findon, near Worthing, by permission of Lord Henry Thynne. The conditions specified that a weight of two pounds, as representing the weight of recording meteorological instruments, should be carried, and that the medal should be given for the highest flight attained by a single kite above 3000 ft. The altitude of the kites was to be determined by trigonometrical observations.

The locality proved to be admirably adapted for the competition under the conditions of weather prevailing at the time. A light wind from the South-west blew up the slope of the Downs in the morning, and increased to a steady breeze in the afternoon, backing somewhat to the Southward as the day, which was beautifully fine, went on.

It was understood that observations of the altitude of the kites should be commenced after the lapse of an hour from the signal for starting. By 2.45 p.m. stations for the kite reels had been arranged, 200 yards apart, along the slope of the Downs, and two stations for the theodolites, 700 yards apart, were selected, from which the kite stations were visible, and which were likely to command an uninterrupted view of the kites during the flight. The responsible duty of carrying out the measurements with the theodolites and the auxiliary chaining was most kindly undertaken by Mr. J. E. Dallas and Mr. W. F. Mackenzie, of the Royal Indian Engineering College, Cooper's Hill, and the success of the arrangements was due in no small degree to the assistance afforded by these gentlemen.

At 2.45 the signal was given to start, and at 3.45 observations of height commenced. The synchronism of the observations of any particular kite from the two stations was secured at first by a prearranged code of signals from one theodolite station to the other, and subsequently by telephone between the two stations. Eight kites were entered for the competition, but only six appeared on the ground, and only four reached a height sufficient to require trigonometrical determination. These were a Hargrave kite of rhomboidal cross section, with four bands of linen, by Mr. H. R. Salmon; a kite of special design, by Mr. S. F. Cody, having the appearance in the air of a very large bird; a similar kite by Mr. L. Cody, and a Burmese kite by Mr. Charles Brogden.

As the result of the calculations it appears that the greatest height measured

for Mr. Salmon's kite was 1250 ft., for Mr. L. Cody's 1476 ft., for Mr. Brogden's 1816 ft., and for Mr. S. F. Cody's 1407 ft., and therefore none reached the minimum height required for the award of the medal. This unfortunate result was probably due to the fact that the wind, which had gradually increased from a light air as the sunshine continued, was a surface wind and fell off in strength at some little height above the surface. The average heights of the several kites, from the four observations of each, were 1189 ft., 1271 ft., 1554 ft., and 1326 ft. respectively.

At 4.45 the signal was given to haul in the kites, and all but one were safely brought back. The wire of this one had become entangled in the trees, and the kite was still in the air when the majority of the visitors had left the ground. The winding-gear was in each case hand gear.

The supervision of arrangements for the competition was entrusted to a jury consisting of Dr. W. N. Shaw, F.R.S. (Chairman), Prof. C. V. Boys, F.R.S., Mr. E. P. Frost, J.P., D.L., Sir Hiram Maxim, Dr. Hugh Robert Mill, Mr. E. A. Reeves, and Mr. Eric Stuart Bruce, Secretary of the Aeronautical Society.

The Society and its energetic Secretary are to be congratulated upon having carried out successfully a series of arrangements that were necessarily elaborate, and not free from difficulties of many kinds.—*Nature*, July 2, 1903.

Climate of Wei-Hai-Wei.—The territory of Wei-Hai-Wei, which was leased to Great Britain by China in 1898, lies in lat. 37° 10′ N., long. 122° 10′ E., and is situated in the Chinese province of Shantung. It comprises the island of Liu Kung, all the islands in the bay of Wei-Hai-Wei, and a belt of land 10 miles wide along the entire coast line. The total area is about 285 square miles.

Mr. J. H. S. Lockhart, the Commissioner of this Dependency, in his Report to the Colonial Office for the year 1902, gives the results of the meteorological observations made by Major W. H. Starr, R.A.M.C., for the four years 1899-1902.

Major Starr's remarks on the climate are as follows:—Having been resident in the Colony for the past four years, I am able to give the meteorological observations for each year from 1899, inclusive.

Situated in the North Temperate Zone on the sea-coast, and being in fact a small promontory, the climate presents neither extremes of great heat nor cold. One year varies somewhat with another, and the year under consideration may be considered a fairly normal one.

January, February, and March are the coldest months, but even in the winter bright sunshine is the rule. The winter is dry and extremely bracing and exhilarating. The cold is only intense when a strong North wind prevails. 15° F. was the lowest temperature recorded in 1902. The weather begins to get warm in May; June, July, and August are the hottest months. The heat is never excessive, and punkahs are nearly a luxury.

In 1902 rain fell on 73 days, which is about the normal. The total rainfall was 28·84 ins. The two previous years had been dry ones, only 15·76 ins. falling in 1900, and 17·16 ins. in 1901. In 1899 22·36 ins. was recorded. The average for the four years would be 21·3 ins., which is probably below the normal.

June, July, and August are the rainy months, and account for more than half the annual rainfall as a rule. This year the rainfall was continued in September and October, over four inches to each month. September, October, and November may be considered the most pleasant months.

In the spring the high winds are usually prevalent, and fogs occur in the rainy season.

On the whole the climate is a most excellent one, second to none in the

East. It compares most favourably with Shanghai, Hong-Kong, and other ports, and is better than that of Japan. Invalids from the south feel the benefit of the change almost at once.

Month.	1899.							1900.						
	Temperature.					Rainfall.		Temperature.					Rainfall.	
	Extreme.		Mean.			Amount.	No. of Days.	Extreme.		Mean.			Amount.	No. of Days.
	Max.	Min.	Max.	Min.	Mean.			Max.	Min.	Max.	Min.	Mean.		
	°	°	°	°	°	in.		°	°		°	°	in.	
January	48·0	14·0	43·7	25·2	34·5	·14	4	42·0	15·0	30·3	22·1	26·2	·19	6
February	52·5	20·5	42·2	28·1	35·1	·63	3	49·0	15·0	38·7	25·6	32·1	·04	2
March	64·0	29·0	49·8	39·7	44·8	·31	4	58·5	21·0	46·4	33·7	40·1	·92	3
April	80·0	33·0	61·2	45·9	53·5	·01	2	80·5	31·0	55·5	43·7	49·6	·44	7
May	88·0	50·0	74·6	57·0	65·8	·66	5	87·0	45·0	70·8	54·8	62·8	1·55	5
June	84·0	56·0	77·2	63·2	70·2	4·20	12	93·5	55·0	75·1	61·1	68·1	1·84	9
July	88·0	63·0	80·7	70·9	75·8	9·59	11	96·0	64·0	82·1	70·3	76·2	3·83	7
August	91·5	64·0	82·5	72·3	77·4	3·71	6	93·0	67·0	83·6	70·2	76·9	3·17	9
September	85·5	53·0	77·8	64·7	71·2	1·81	5	85·5	59·0	79·7	67·9	73·7	·44	4
October	76·5	41·5	63·1	51·9	57·5	·64	5	77·5	43·0	66·6	54·2	60·4	·98	9
November	65·5	32·0	52·8	40·8	46·8	·67	4	70·0	29·5	53·6	40·4	47·0	·28	3
December	54·5	20·0	42·8	31·8	37·2	·59	5	53·5	17·5	39·1	30·0	34·5	2·08	9
Year	91·5	14·0	62·4	49·3	55·8	22·36	66	96·0	15·0	60·1	47·8	54·0	15·76	73

Month.	1901.							1902.						
	Temperature.					Rainfall.		Temperature.					Rainfall.	
	Extreme.		Mean.			Amount.	No. of Days.	Extreme.		Mean.			Amount.	No. of Days.
	Max.	Min.	Max.	Min.	Mean.			Max.	Min.	Max.	Min.	Mean.		
	°	°	°	°	°	in.		°	°	°	°	°	in.	
January	44·0	15·5	36·0	26·0	31·0	1·68	7	48·0	15·0	37·0	27·0	32·0	·12	6
February	46·2	10·5	32·0	23·0	27·5	·06	2	48·0	20·0	37·0	27·0	32·0	·75	6
March	64·5	20·0	47·0	32·0	39·5	·07	3	65·0	22·0	46·0	36·0	41·0	1·99	11
April	79·0	31·0	57·0	43·0	50·0	·17	3	88·0	37·0	60·0	46·0	53·0	1·97	8
May	87·5	46·5	67·0	53·0	60·0	1·31	3	98·0	55·0	72·0	61·0	66·5	·27	2
June	90·0	57·5	78·0	63·0	70·5	1·09	5	89·0	62·0	76·0	63·0	69·5	1·16	5
July	90·1	63·0	80·0	68·0	74·0	1·35	6	94·0	69·0	79·0	69·0	74·0	5·18	7
August	87·5	64·5	82·0	72·0	77·0	1·78	6	86·0	60·0	79·0	68·0	73·5	7·19	11
September	80·5	60·0	76·0	66·0	71·0	3·13	6	88·0	50·0	77·0	64·0	70·5	4·66	5
October	85·0	38·0	65·0	56·0	60·5	4·18	8	76·0	47·0	70·0	57·0	63·5	4·23	4
November	66·5	27·5	53·0	41·0	47·0	·21	5	74·0	37·0	59·0	46·0	52·5	·53	3
December	50·5	11·0	37·0	27·0	32·0	2·14	18	62·0	23·0	42·0	32·0	37·0	·49	5
Year	90·1	10·5	59·2	47·5	53·3	17·17	72	98·0	15·0	61·2	49·7	55·4	28·84	73

This Dependency should be the sanatorium of the Far East from Singapore northwards. For periods of short leave from the Straits and Hong-Kong it should prove most useful for invalids.

A feature of the rainy season here is that the fall is not equally distributed, as is seen from the appended returns, and moreover every year a heavy fall of several inches occurs in 24 hours, and owing to the natural features of the country most of this water pours off the hills in large volumes, requiring surface drains of considerable size to take it off. Much damage is frequently done to roads and bridges, etc., by these sudden heavy rainfalls.

The meteorological observations are now being sent daily to the Hong-Kong Observatory, and have been found valuable in assisting the work there.

Meteorological Observations in the British Central Africa Protectorate.—We have received a set of tables giving the results of the meteorological observations made at a number of stations in the British Central Africa Protectorate for the year 1902. The following summaries will no doubt be found to be of interest :—

TEMPERATURE.

MONTH.	Chiromo.			Chikwawa.			Blantyre.			Fort Anderson.		
	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.
1902	°	°	°	°	°	°	°	°	°	°	°	°
January .	77·5	87·5	79·0	75·2	91·1	78·0	69·6	77·5	69·9	72·0	79·7	73·9
February .	79·4	90·5	77·7	73·1	90·9	75·1	67·6	76·5	69·3	71·5	81·5	72·9
March .	77·6	85·1	75·3	73·6	85·4	75·3	67·0	75·1	68·8	71·1	84·8	71·1
April .	71·9	88·3	74·5	70·8	87·2	76·5	65·3	80·0	68·0	64·3	96·4	70·5
May . .	65·0	82·0	69·7	67·0	83·4	69·0	57·5	71·9	62·0	62·6	79·3	64·2
June . .	62·7	80·9	67·0	66·3	85·4	68·7	54·4	72·3	65·8	58·7	73·6	60·0
July . .	61·5	80·9	64·0	56·8	74·9	61·7	54·5	70·9	59·7	57·0	70·0	55·0
August .	65·0	86·0	71·0	59·6	87·2	64·5	58·2	76·8	64·4	60·0	80·1	68·6
September	71·1	92·7	74·7	71·8	93·1	82·1	68·0	79·6	70·1	69·7	80·3	73·3
October .	73·0	95·4	77·3	74·1	93·6	84·5	67·6	79·9	71·0	60·7	80·4	70·2
November.	78·7	99·3	81·7	79·5	98·6	86·7	72·3	83·0	73·8	71·0	84·6	70·1
December.	77·5	95·9	81·3	79·5	96·4	84·1	69·3	80·6	72·7	70·0	86·0	70·3
Means .	71·7	88·7	74·4	70·6	88·9	75·5	64·2	77·0	67·9	65·7	81·4	68·3

MONTH.	Zomba.			Liwonde.			Fort Johnston.			Nkata Bay.			Karonga.		
	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.	7 a.m.	2 p.m.	9 p.m.
1902	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Jan. .	69·1	78·2	69·4	75·1	86·1	77·3	74·1	82·6	75·0	...	...	...	76·5	84·3	...
Feb. .	67·7	77·4	68·8	73·6	87·2	78·0	74·0	82·5	74·5	...	..	...	76·1	83·8	...
Mar. .	66·1	74·8	67·9	72·8	86·0	76·8	72·8	79·6	73·9	73·2	84·6	73·7	76·4	85·3	...
Apr. .	64·2	78·6	67·6	69·5	89·6	78·5	70·4	84·5	74·4	72·3	84·2	73·6	74·5	83·9	...
May .	59·1	73·2	62·8	63·0	82·5	71·8	63·7	82·6	70·2	67·8	79·7	67·4	72·3	82·2	...
June .	56·5	72·8	61·9	61·0	81·0	66·7	59·5	78·7	67·3	64·0	77·1	64·0	70·2	80·3	...
July .	55·8	71·9	61·4	60·8	84·5	62·9	58·9	79·2	68·1	60·5	73·6	60·8	...	...	...
Aug. .	58·8	76·3	65·6	66·3	90·0	72·7	63·7	82·6	70·0	63·6	75·6	63·5	68·9	79·6	...
Sept. .	65·8	81·5	71·1	76·0	93·8	82·3	69·6	88·0	75·9	69·3	81·7	70·5	78·1	85·7	...
Oct. .	66·8	81·8	71·8	74·2	92·2	78·9	73·2	89·3	77·1	73·8	84·0	74·0	..	...	...
Nov. .	71·6	83·3	73·1	78·1	92·9	83·3	76·5	90·5	78·8	50·3	55·8	48·6	81·3	88·2	...
Dec. .	68·7	84·3	72·6	78·7	90·2	82·0	73·1	88·2	78·3	71·3	81·6	79·6	78·0	88·0	...
Means .	64·1	77·8	67·8	70·7	96·3	75·9	69·1	84·0	73·6	...	...	...	...	...	...

Rainfall.—The following table gives the Monthly and Annual Rainfall at 28 stations for the year 1902:—

Station.	Altitude.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Lower Shire.	ft.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Port Herald	115	12·19	5·72	4·84	...	...	...	...	·32	...	2·67	·83	·54	27·11
Chiromo	125	5·42	·61	11·87	·22	·63	·79	·52	·05	·06	1·11	·93	·61	22·82
Chikwawa	127	10·72	4·72	5·64	...	·75	2·49	1·77	·25	·15	·44	1·16	·80	28·89
Upper Shire.														
Liwonde	1150	16·49	2·99	4·22	·57	...	...	...	..	...	...	2·11	3·70	30·08
Fort Johnston	1263	13·32	2·13	3·30	·53	·33	·02	...	·06	·71	·07	2·28	4·72	27·47
West Shire.														
Mwendagombe	3800	12·19	6·71	9·43	2·94	·64	·17	·20	·21	·35	·74	2·68	13·52	49·78
Mbango	3500	12·51	5·14	10·41	·22	·65	·21	·17	·08	...	·45	1·78	6·65	38·27
Angoniland.														
Fort Mlangeni	3500	15·37	7·39	9·02	·21	·13	...	...	·05	...	·30	1·90	4·32	38·69
Chiole	3500	16·23	6·79	7·08	...	·60	...	...	...	...	·07	3·81	6·28	40·86
Mlanje.														
Fort Anderson	3300	17·99	11·89	17·61	2·00	3·85	1·80	1·57	2·30	·92	5·13	7·80	2·87	75·73
S. and S.E.														
Lauderdale	3200	20·61	16·79	16·27	2·47	4·71	1·31	1·72	Record not complete					
Thornwood	3000	13·04	8·13	18·65	·76	2·76	·71	·98	1·60	·31	6·32	10.93	2·20	66·39
North.														
Lukulesi	2800	14·84	6·49	7·24	·30	...	...	...	...	...	...	2·33	1·57	32·77
Tuchila Plateau	6000	16·97	8·47	15·57	·13	·85	·10	...	·38	...	·27	7·26	3·16	53·16
Blantyre.														
Collectorate	3000	15·20	10.26	3·65	·54	·04	·08	...	...	...	...	1·50	1·34	32·61
Myara	3000	9·51	7·69	6·46	·83	·51	·23	·27	...	...	·49	5·01	2·92	33·92
A.L.C. Gardens	3000	16·34	12·27	4·02	·87	...	·03	·05	Record not complete					
Chipande	3000	11·33	6·98	4·24	1·90	...	·20	·15	...	...	·27	4·19	2·26	31·72
Namadzi.														
Magomero	3200	14·51	10·55	6·88	...	...	...	...	...	...	...	9·73	1·24	42·91
Zomba.														
Observatory	2948	17·96	11·24	9·07	·37	·46	...	·22	·28	·01	·34	4·49	4·08	48·52
Mlumbe's Peak	6000	19·40	10·51	9·07	...	...	...	·96	·43	...	·80	·62	2·70	44·49
Sanatorium	400	21·13	11·61	10·41	...	...	...	·82	·58	...	1·41	2·83	2·68	51·47
Chirungas	2500	16·94	8·72	9·11	·16	·90	...	·09	·15	·04	...	2·05	2·53	40·69
Songani	2300	17·05	8·14	10·30	1·57	·18	...	...	·07	.08	...	1·64	1·35	40·38
Domasi Mission	3000	16·23	5·55	9·94	...	...	...	...	·04	...	·28	1·14	4·56	37·74
West Nyasa.														
Nkata Bay	1400	...	...	13·65	9·04	4·43	...	...	2·23	...	·03	·81	13·21	43·40
North Nyasa.														
Karonga	1260	8·22	6·31	20·82	14·78	1·78	...	...	...	...	...	·50	6·40	58·81
Fort Hill	3000	11·80	7·95	5·10	2·51	...	...	...	...	...	·30	1·43	6·54	35·63

RECENT PUBLICATIONS.

British Rainfall, 1902. *On the Distribution of Rain over the British Isles during the year* 1902, *as observed at about* 3500 *Stations in Great Britain and Ireland, with Articles upon various Branches of Rainfall Work.* Compiled by H. Sowerby Wallis, and Hugh Robert Mill, D.Sc., LL.D. London, 1903. 8vo. (76 + 250 pp. and 8 plates.)

The number of rainfall records published in this volume are: 2712 for England, 248 for Wales, 472 for Scotland, and 204 for Ireland, the total being 3636, which is an increase of 130 on the previous year. The year 1902 was dry in every division of the British Isles, as will be seen from the following figures:—

	Ins.		Per cent.
England and Wales	28·01	Difference from average	−18
Scotland	38·73	,, ,,	−14
Ireland	37·56	,, ,,	−9

There was thus a general deficiency of rain in each of the three kingdoms. For the British Isles as a whole the deficiency of rainfall comes out as 15 per cent. This is a very remarkable figure, which has only once been surpassed (1887) and once equalled (1893) since 1881. The value is rendered the more remarkable by the fact that it was the second dry year in succession, the cumulative deficiencies being as follows:—

	Total Fall.		Difference from Average of 30 years.		
	1901.	1902.	1901.	1902.	Total.
	ins.	ins.	%	%	%
England and Wales	29·83	28·01	−13	−18	−31
Scotland	41·04	38·73	−8	−14	−22
Ireland	40·33	37·57	−4	−9	−13
British Isles	34·85	32·71	−10	−15	−25

The largest rainfall during the year 1902 was 157·09 ins. at Ben Nevis Observatory, and the least 15·12 ins. at Oakleigh, Higham, Kent. The maximum fall in one day was 5·92 ins. at Ben Nevis Observatory on May 27.

In addition to the usual information and data bearing on rainfall, this volume also contains two articles, viz.:—

(1) "On the Rainfall at Camden Square for the 45 years 1858 to 1902," by H. Sowerby Wallis. With the close of the year 1902, the rainfall records at Camden Square extended over a period of 45 years, and the records have been fully discussed by Mr. Wallis. The chief results may be summarised as follows:—

	Ins.	Rainy Days.
Average rainfall, 45 years	24·99	160·5
Wettest year, 1878	34·08	172
Driest year, 1864	16·93	110
Greatest monthly total, August 1878	6·72	22
Least monthly total, February 1891	·01	1

The greatest amount in one day was 3·278 ins. in June 1878. There is only one instance in the 45 years of two days in succession with more than 1 in.—namely June 5 and 6, 1884, with 1·47 in. and 1·00 in. respectively. In the 45 years there were thirteen months in which more than 5 ins. were recorded, and fifteen with a total of less than 0·40 in.

(2) "The Number of Rainy Days in 1902 as compared with the average," by Hugh Robert Mill, D.Sc., LL.D. The results of this article may be briefly summarised as follows:—

	Period 1891-1902. No. of Rainy Days.	Period 1891-1902. Mean Rainfall.	Year 1902. No. of Rainy Days.	Year 1902. Mean Rainfall.
		ins.		ins.
England and Wales	181	36	184	31
Scotland	206	44	210	38
Ireland	216	42	220	39
British Isles	197	40	200	35

Dr. Mill shows that the average number of rainy days per annum increases from 150 in the south-east of England to over 250 in the north-west of Ireland and Scotland, and that in all parts of the country the year 1902 had 2 per cent more rainy days than the average, while the total rainfall was about 15 per cent less than the average.

We regret to learn that owing to ill health Mr. H. Sowerby Wallis has found it necessary to resign the active editorship of *British Rainfall* to Dr. H. R. Mill (see p. 309).

"*Die Luftströmungen auf dem Gipfel des Säntis,* 2504 *m., und ihre jährliche Periode*": von J. HANN. *Sitzungsberichte der Kaiserl. Akademie der Wissenschaften in Wien.*

As five complete years of the Säntis observations are available, Dr. Hann gives the following summary:—The North Component reaches its highest value in January and February, and its least in July and August. During the six months from June to November it remains below its annual mean, and from December to May it remains above it. April shows hardly any deviation. The East Component shows a similar march to the foregoing, but the winter maximum is more strongly marked, as is also the minimum from June to September.

The South Component has even a more strongly marked march: it remains below the mean from March to August, and remains above it from September to February. The maximum is in October and November, the minimum in June. With the West Component the yearly period is less regular, but still quite decided. A strong maximum in July and August, and a minimum in April, which is intensified in May.

Jahrbücher der König. und Reichs-Anstalt für Meteorologie und Erdmagnetismus. Officielle Publikation. XXXII. Band. 1902. II. Teil. Budapest, 1903. 4to. (3 + 120 pp. and 12 plates.)

This part of the *Jahrbuch* contains the daily meteorological and also the magnetical observations made at the Central Observatory at O-Gyalla.

Meteorological Observations made at the Perth Observatory and other places in Western Australia during the year 1901, *under the direction of* W. ERNEST COOKE, M.A., *Government Astronomer.* (135 pp. and maps.) Folio.

This volume contains the Report to the Hon. Colonial Secretary by W. E. Cooke, and also six sections as follows:—(1) Meteorological Observations at Perth Observatory; (2) Monthly and Annual Readings at Perth (Observatory and Gardens); (3) Monthly Abstract of Results at 44 Stations in Western

Australia, Monthly Climatological Tables for the Whole State, and some observations on Terrestrial Radiation, Evaporation, and Wind Velocity; (4) Daily Barometer and Wind Observations at Lighthouses; (5) Rainfall; and (6) Climate and Rainfall Maps.

Weather Forecasts are issued by the Observatory. The following figures show the percentage of success for the year 1901:—

		Correct.	Partially Correct.	Wrong.
		%	%	%
General forecasts for the whole State	issued at Noon	93	6	1
	,, ,, 8 p.m.	90	9	1
Special forecasts for the Goldfields	,, ,, Noon	91	8	1
	,, ,, 8 p.m.	90	8	2

Meteorologische Zeitschrift. Redigiert von Dr. J. HANN und Dr. G. HELLMANN. June-August 1903. 4to.

The principal articles are:—"Über den Vorschlag Wildes zur Einschränkung des Begriffs 'Föhn'": von R. Billwiller (7 pp.). This discussion was instigated by reading Trabert's account of the North-west Föhn at Innsbruck, December 18, 1902. It is a very interesting paper, and well merits reading by those interested in Föhn phenomena.

"Bericht über die internationale Experten-Konferenz für Wetterschiessen in Graz" (9 pp.). This is a careful abstract of the proceedings. There was a very considerable difference of opinion as expressed by the different speakers, but the general summary is to the effect that prospects are encouraging as regards further prosecution of the experiments.

"Die Schwankung der Aufblühezeit und die Temperatur in Ungarn": von J. Hegyfoky (10 pp.). This is a paper which will mainly interest phenologists.

"Über eine verbesserte Anordnung des Schreiberschen Gewitterregistrators": von K. von Kutschig und K. Poetzl (5 pp.). This is an account of a new brontometer working by electricity.

Among the *Kleinere Mitteilungen* is a paper on the utilisation of the "Sonnwendstein" for the general weather forecasting. This is interesting as regards the much-debated question of the utility of the Ben Nevis observations for the same purpose.

"Zur Morphologie der Wolken des aufsteigenden Luftstroms": von K. Mack (18 pp.). Herr Mack points out that in a former paper in the *Meteorologische Zeitschrift*, vol. xv., he showed that very probably circular cloud rings with horizontal axes come into being. He then quotes several occasions on which he noticed clouds of ring shape, and then goes on to notice clouds of mushroom form, of which he gives many instances, and also cap-shaped clouds. He concludes by saying that the phenomena of cloud formation resemble closely the laboratory experiences with liquids and gases, and that he is convinced that these horizontal rings play an important part in ascending currents of air. The paper well merits study.

"Die Lage der Troglinie in einer elliptischen Zyklone": von M. Kossatsch (5 pp.). This is a short mathematical discussion of the movements of the trough of an elliptical cyclonic storm.

"Über Blitzphotographien": von L. von Szalay (7 pp.). This is a paper worth study by those who are photographing lightning, especially with regard to the broad ribbon-like appearance sometimes noticed.

"Die meteorologischen Ergebnisse der Expedition Sr. M. Schiff 'Pola' in das Rote Meer 1895-98": von J. Hann (14 pp.). This is a summary of this Report of the Red Sea Expedition, published by the Vienna Academy.

Observations made at the Royal Magnetical and Meteorological Observatory at Batavia. Published by order of the Government of Netherlands East-India. Vol. 24. 1901. Batavia, 1903. (11 + 195 pp. and plate.) 4to.

This volume contains the meteorological and seismometric observations for the year 1901, and also three appendices, viz.: (1) Additions to the library for the period March 1-September 1, 1902; (2) On Wind, as recorded at the Batavia Observatory with Beckley's anemograph during the period 1891-1900; and (3) Observations made during the sun's total solar eclipse on May 18, 1901.

Über die tägliche Drehung der mittleren Windrichtung und über eine Oscillation der Luftmassen von halbtägiger Periode auf Berggipfeln von 2 bis 4 km. Seehöhe. Von J. HANN. *Sitzungsberichte der Kaiserl. Akademie der Wissenschaften in Wien.* Mathem.-Natur. Klasse von 11 December 1902. 8vo.

In this paper Dr. Hann deals, with his usual thoroughness, with all the publications on the subject which have hitherto appeared, and especially treats of the records from the Sonnblick, the Säntis, the Obir, and Pike's Peak. The paper itself is so detailed that it does not lend itself to analysis.

U.S. Department of Agriculture. Weather Bureau Report of the Chief of the Weather Bureau. 1900-1901. Volume II. Washington, 1902. 4to. 1005 pp. Maps and Plates.

This volume is devoted to the "Report on the Barometry of the United States, Canada, and the West Indies," by F. H. Bigelow. The report contains a revision of the meteorological data which have become available since the opening of the Government service in 1871, in order to prepare it on modern scientific principles for the forecasting work of the Bureau. It contains the material necessary for constructing daily weather maps on three planes—the sea-level, the 3500-foot plane, and the 10,000-foot plane; also normal values of the pressures, temperatures, and vapour pressures at the stations and on these three planes. This work will be a standard of reference not only for the Weather Bureau, but for all branches of science requiring such data. The United States has thus taken the lead in reducing its barometric observations to a standard system, and it is hoped that other countries will soon be able to do a similar work for their own observations.

Zur Theorie der vertikalen Luftströmungen. Von Dr. FELIX M. EXNER. Aus den *Sitzungsberichten der Kaiserl. Akademie der Wissenschaften in Wien.* Mathem.-Natur. Klasse: Bd. cxii. Abl. IIa. Mai 1903. 8vo.

This is a mathematical discussion of the subject of vertical movement of the atmosphere, with critical notices of the works of Guldberg and Mohn, Teisserenc de Bort, and Angot. Dr. Exner takes for $\frac{d^2p}{dx^2} + \frac{d^2p}{dy^2}$ the symbol $\nabla^2 p$, in which p is pressure and x and y rectangular co-ordinates, and he finds finally that at the earth's surface, when the conditions are quiet, $\nabla^2 p$ is >0 with low pressure, barometer rising, and <0 with high pressure, barometer falling; at upper levels high pressure is accompanied by rising movements, low pressure by falling movements.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

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—— Note on the Barometric Pressure at Colon. *Monthly Weather Review, Washington,* **31** (188).

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